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Information sharing for medical triage tasking during mass casualty/humanitarian operations

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THESIS

INFORMATION SHARING FOR MEDICAL TRIAGE TASKING DURING MASS CASUALTY/HUMANITARIAN OPERATIONS

by

Lillian A. Abuan

December 2009

Thesis Co-Advisors: Albert Barreto III
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This thesis will focus on field testing and evaluating the capabilities of a smartphone-based system and associated equipment for "First Responder Networking." Further, we will identify information sharing requirements for supporting a medical triage tasking during mass casualty and humanitarian operations. These requirements will be implemented, tested and evaluated against the capabilities of the TwiddleNet system for passing/sharing of patient information and records, in the form of text, photos and voice, rapidly disseminated to those involved with the Mobile Emergency Command Post unit and the Joint Operations Command Center. This will facilitate communication via synchronized backhaul or satellite communiqué from the disaster site to other medical facilities across a globally distributed network. For example, land based military medical units, naval hospital ships, stateside medical centers via tele-medicine, etc. The applicability of these efforts to the DoD will be specifically tested via integrated mass casualty/triage scenarios and simulated humanitarian operations.

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INFORMATION SHARING FOR MEDICAL TRIAGE TASKING DURING MASS CASUALTY/HUMANITARIAN OPERATIONS

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Submitted in partial fulfillment of the
requirements for the degree of

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from the

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ABSTRACT

This thesis will focus on field testing and evaluating the capabilities of a smartphone-based system and associated equipment for “First Responder Networking.” Further, we will identify information sharing requirements for supporting a medical triage tasking during mass casualty and humanitarian operations. These requirements will be implemented, tested and evaluated against the capabilities of the TwiddleNet system for passing/sharing of patient information and records, in the form of text, photos and voice, rapidly disseminated to those involved with the Mobile Emergency Command Post unit and the Joint Operations Command Center. This will facilitate communication via synchronized backhaul or satellite communiqué from the disaster site to other medical facilities across a globally distributed network. For example, land based military medical units, naval hospital ships, stateside medical centers via tele-medicine, etc. The applicability of these efforts to the DoD will be specifically tested via integrated mass casualty/triage scenarios and simulated humanitarian operations.

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I. INTRODUCTION

Today’s smartphones are just as powerful as regular personal computers (PCs) were a few years ago. Their advanced capabilities can support a number of smartphone-based systems. These powerful devices can be converted to personal servers to be used for instantaneous data capture and dissemination in support of “First Responder Information Sharing.” This thesis tests and evaluates the capabilities of a smartphone-based system and associated equipment for “First Responder Networking.” TwiddleNet, a wireless system implemented using handheld-based infrastructure, is the First Responder application used as the platform for instantaneous data capture and dissemination.

A. DEFINITION OF TWIDDLE

Definition: (Verb) - To twist, move, or fiddle with something, typically in a purposeful or nervous way.

1. Twiddle one’s thumbs – rotate one’s thumbs around each other with the fingers linked together.
2. Be bored or idle because one has nothing to do

Today’s cell phones are constantly twiddling… awaiting calls or data to be passed!

B. TWIDDLENET APPLICATIONS

1. Advanced Handheld Communications Hardware

Use of advanced handheld communications hardware via smartphones to facilitate:

a. Instantaneous capture of data in support of medical triage that can be tagged and disseminated using any accessible mobile WiFi network.

b. Mobile Emergency Command Post team members and First Responder groups maintain complete autonomy of all captured data, which is shared among specified team members, stored for redundancy by the Mobile Emergency Command Post server and later discriminately disseminated or shared.

c. System parameters that allow exploitation of multiple communications that are limited only by the physical limits of the communications, which in turn are limited only by the physical limits of the hardware

2. Gateway

A gateway is established involving mobile personal servers that run on networked handheld devices or smartphones where the server content is completely autonomous. The privacy of personal information remains intact due to the contained WiFi network cloud that is created by the TwiddleNet access point, or the private local WiFi cloud maintained by the Network Operations Center (NOC) of the onsite Command and Control Center.

C. PRIMARY OBJECTIVES

Our primary objectives will be to determine the functional performance of the TwiddleNet system and document software developments as it relates to First Responder capabilities and medical triage. This work will identify on identifying sharing requirements for supporting scalable medical triage tasking teams during mass casualty and humanitarian operations and perform a system-level test and evaluation of the TwiddleNet system.

D. SMARTPHONE CAPABILITIES OF CONTENT CAPTURE

The smartphone capabilities for data content capture include:

- Immediate content capture and dissemination.
- Full autonomy of content and data.
- Instantaneous data tagging.
- Selected group sharing.

E. PRIVACY REQUIREMENTS FOR FIRST RESPONDERS

1. General Specifications

There must be a separation of information from different domains and groups using the same system in the local TwiddleNet network or local adhoc network. This will allow access to content and data by First Responder team members, which is otherwise inaccessible to individuals outside of the First Responder teams; and a Push/Pull coordination for all data, to facilitate data being "Pushed" to specified recipients and data that can be accessed and downloaded by any recipient or team member.

2. Specific Requirements

a. Local adhoc networks or access to the TwiddleNet Mobile network, with a dedicated block of IP addresses to accommodate all TwiddleNet components. This will provide closed communication with the local network administrator and provide a standard of understanding by all users within the local network, not to interfere with dedicated IP addresses for the TwiddleNet system.

b. Many privacy threats related to mobile networks are a constant issue within the Information Operations Domain. The Military must protect communications related to force protection to mitigate threats to content privacy. Safeguarding all personal information, with respect to medical triage operations, is a criticality.

c. Our testing will assume that eavesdropping and surveillance are not being conducted. Our testing is focused on the functional requirements rather than the security of the network.

F. OBJECTIVES

1. Test and Evaluate Deployment

Our objective is to test and evaluate the TwiddleNet System and the setup of the TwiddleNet Mobile Emergency Command Post for First Responder teams in support of Humanitarian Assistance missions and Medical Triage operations.

2. Research Question

a. *“How can the DoD deploy a Mobile Emergency Command Post for* ‘First Responder Capability’ *when there is no available network infrastructure?”*

3. Secondary Research Questions

a. “How can victims be medically triaged and information stored and disseminated across a globally shared network?”

b. *“What is the current and future state of the DoD’s on-site disaster* ‘First Responder Capabilities’ *and Mobile Emergency Command Posts?”*

G. SCOPE

Interest is focused on test and evaluation of the following:

1. Information capture and sharing within groups of authorized users.

2. TwiddleNet group streaming capabilities.

3. Group sharing options within the local adhoc network or the TwiddleNet Mobile Network.

4. Utilization of TwiddleNet Fly Away Kit (FLAK) for deployment of rapid response teams.

5. Utilization of the “TwiddleNet Gateway” abilities to communicate with specified receivers (e.g., NPS TwiddleNet Network Lab).

6. Incorporation of satellite communications via a Broadband Global Area Network (B-GAN) to create a stable backbone for reach-back options to other distant or global medical facilities.

HP iPAQ smartphones with mobile network system capabilities will be used as a platform for the TwiddleNet system implementation. The scope is limited to changes to the TwiddleNet software and architecture and the equipment capabilities.

The research is limited to the application layer of the OSI Reference Model as changes to the operating system and network stack are beyond the availability and visibility of the researcher.

Testing will be conducted during specified field scenarios equivalent to natural disasters such as Hurricane Katrina, the Boxing Day Tsunami of 2004, and other types of mass casualty circumstances.

H. ORGANIZATION/METHODOLOGY

Research will be conducted in the following phases:

1. Phase 1: Development of Metrics and Test Plan

This phase will include the necessary academic review of existing technical material and hardware for the TwiddleNet network. Measure of Performance and Measure of Effectiveness (MOP/MOE) will be created. These MOPs/MOEs will be used to develop an effective test and evaluation plan.

2. Phase 2: Base-Lining and Experimentation

This will be an overview of the utilization of testing and evaluation plan used with the TwiddleNet system when integrated with various streams of the network data. The TwiddleNet System will be connected to the Naval Postgraduate School (NPS) Cooperative Operations and Applied

Science and Technology Studies (COASTS) adhoc network during the following Field Experiments (FEX):

a. 2008 COASTS Camp Roberts FEX III.

b. 2008 COASTS Thailand FEX IV/V.

c. 2009 COASTS Camp Roberts FEX II/III.

During these exercises, determination of usefulness and operating procedures for future use within a DoD supported network will be explored. The TwiddleNet system will be connected to multiple networks in other operating environments through satellite communication utilizing a B-GAN while the TwiddleNet team is deployed to remote areas, such as Thailand, to further the perspectives of system effectiveness. The TwiddleNet team will utilize the Gateway Application (introduced in the 4th Iteration) for reach-back to global or remote C2 sites (e.g., NPS TwiddleNet Lab, Joint Operations Command and Control (JOCC)/Tactical Operations Center (TOC))

3. Phase 3: Analysis of Results and Conclusions

The final phase will consist of analyzing the results of each case study and each simulated natural disaster scenario. The results will be compared to the baselined system and compared to the MOP/MOEs determined in Phase 1.

By comparing the results from the case studies to the baseline and MOP/MOE’s, it will be possible to determine the effectiveness and feasibility of deploying the system in real-world DoD environments.

I. CHAPTER OUTLINE DESCRIPTION

Chapter I gave a brief introduction to the TwiddleNet System. This encompassed the primary objectives of this work, the proposed applications, general and specific system requirements, and the scope and methodology utilized for the evaluation of the TwiddleNet System.

Chapter II will provide an extensive background narration of the first three TwiddleNet iterations. This chapter will also include a breakdown of the TwiddleNet Architecture and the pros, cons, design and operational issues for the first three TwiddleNet iterations.

Chapter III will provide the specific metrics used for determination of feasibility of TwiddleNet iterations 1-3. An overview of applicable areas of use will be provided, along with a thorough description of each TwiddleNet Hardware Component.

Chapter IV will provide an extensive description of Fourth Generation TwiddleNet, to include pros, cons and design flaws.

Chapter V will describe the testing methods used. This will include a breakdown of the Measures of Performance (MOPs) and Measures of Effectiveness (MOEs).

Chapter VI will explain the different scenarios and testing venues that incorporated all four iterations of TwiddleNet, to include test data and results of the first three iterations.

Chapter VII will provide summary and conclusions; discussing how TwiddleNet can be incorporated into DoD applications and future work for the TwiddleNet System.

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II. BACKGROUND

This section provides a general overview of the TwiddleNet system as applicable to a medical triage application. Additional preamble will include specifics of the TwiddleNet architecture and historical details of the TwiddleNet iterations throughout its 2.5-year evolution.

A. TWIDDLENET OVERVIEW

Today’s smartphones are no longer just phones; they are no longer used for just vocal communications. They are just as powerful as regular personal computers (PCs) were a few years ago. They contain at least 600 MHz processors, going as high as 1 GHz (in the very near future). For the new models of smartphones, their memory is often 256 Mbytes with an unlimited amount of storage capacity.

But there are at least two important reasons that illustrate why these little handheld devices are profoundly better than a PC for certain applications:

1. Content Capture Capability – These handheld devices come pre-equipped with the capability to capture images, video, sound, and text.

2. Networking Capability - There are at least four types of networking capability built into today’s smartphones: Global System for Mobile communication (GSM), 2.5 or 3.0 Gig high-speed networking, Wireless Fidelity (WiFi) and Bluetooth. All of these networking modalities are readily available on this little handheld device.

This power can basically enable instantaneous and real-time content capture and dissemination among first responders or military units through the powerful means of TwiddleNet.

TwiddleNet exploits a smartphone-based networking system to harness the untapped resources to create an autonomous network of personal mobile servers. Its usefulness in scalability allows for adjustment to any operational size, either planned or "on the fly" emphasizing the high level of success for any mission.

1. Medical Triage and Information Sharing

Throughout history, natural, accidental and willful disasters have had profound effects on a global scale. On a macro level, the persistent challenges met by first responders at each major disaster site are a lack of a communications system, a preponderance of fractured structures, a lack of situational awareness, fractured command and control organization and retarded deployment of resources. Tragedies such as Hurricane Katrina in 2005, the September 11 attacks of 2001, the Oklahoma City bombing in 1995 and Hurricane Andrew in 1992, medical triaging involving first responders, firefighters, police and military elements, have gleaned from lessons learned due to communication failures. A reliable communication and networking system is critical within the first 24–48 hours of responding to a disaster.

In the realm of crisis and disaster response, the advent of *"Hastily Formed Networks,"* (Denning, 2006) has emerged as a strong solution to support the communication challenge of any major disaster. And within this realm, TwiddleNet has secured a position as a viable and worthwhile initiative. The TwiddleNet system was created and inaugurated in 2005 by two Naval Postgraduate Students (NPS) enrolled in the Computer Science department, Capt. Jonathan Towle, USMC, and LT Christopher Clotfelter, USN [1]. The students recognized the immense communication power within today's mobile devices, offering a variable range of content capturing capabilities, to include acceptably high resolution pictures, videos and sound/voice recordings. They also recognized the significant evolutionary processing power of current mobile devices, surpassing that of legacy PCs of less than four years ago. And finally, they recognized that a strong need existed to streamline the communication process for deployed first responder units; to eliminate the requirements to bring large, bulky components on site or into the field to capture, upload and disseminate important data among the field team members and to the Command and Control center.

B. TWIDDLENET ARCHITECTURE

1. TwiddleNet System

The TwiddleNet system was designed to allow users to utilize smartphones as personal servers; to capture or gather information and data and share instantaneously within a protected WiFi cloud. The premise is based on a "Push/Pull" technology, designed to allow users to "push" information to active recipients and team members or for these same team members to “pull” information from the system database for instantaneous download onto their personal handheld device.

This model of content sharing is fundamentally different from content sharing in other portals such as Flickr [1] and You Tube [2] because after the data is captured, it must then be uploaded onto the portal using a PC to allow others to see it. The consequences that accompany this mode are:

a. This takes time
b. This is harder to use
c. The content is under someone else’s control
d. Data is exposed to the public Internet

But with the TwiddleNet approach, the content is captured, automatically tagged, alerts are sent out to all team members, and whoever receives an alert can retrieve the data with their own handheld devices. And this, “Smart Push/Pull” data processing is a catalyst in the quest for information superiority and Network-Centric Warfare [16].

2. TwiddleNet Programming

The TwiddleNet system was designed to run on a Microsoft Windows® Mobile Operating System. This software application exploits the mobile network by utilizing a

[1] Flickr - Online photo management and sharing tool.

[2] You Tube - Allows people to easily upload and share video clips across the Internet through Web sites, mobile devices, blogs, and email.

“push/pull” technology[3] of data distribution. The user will gather all data and information and while maintaining full control, will distribute to all eligible recipients. Users can control or specify the eligibility of recipients directly on their personal handheld device.

The metadata sent is specifically characterized at creation, which significantly reduces network load and increases network capacity and speed. Each recipient is given an alert upon receipt of the metadata, both auditory and visual. Recipients can then choose to download the data file instantaneously on their personal handheld device, or at a more convenient time.

The TwiddleNet system is comprised of ten components [2], as depicted in Figure 1.

[3] Push: A data distribution technology in which selected data are automatically delivered into the user's computer at prescribed intervals or based on some event that occurs. Pull: The user specifically asks for something by performing a search or requesting an existing report, video or other data type. Browsing the Web is an example of the pull model.

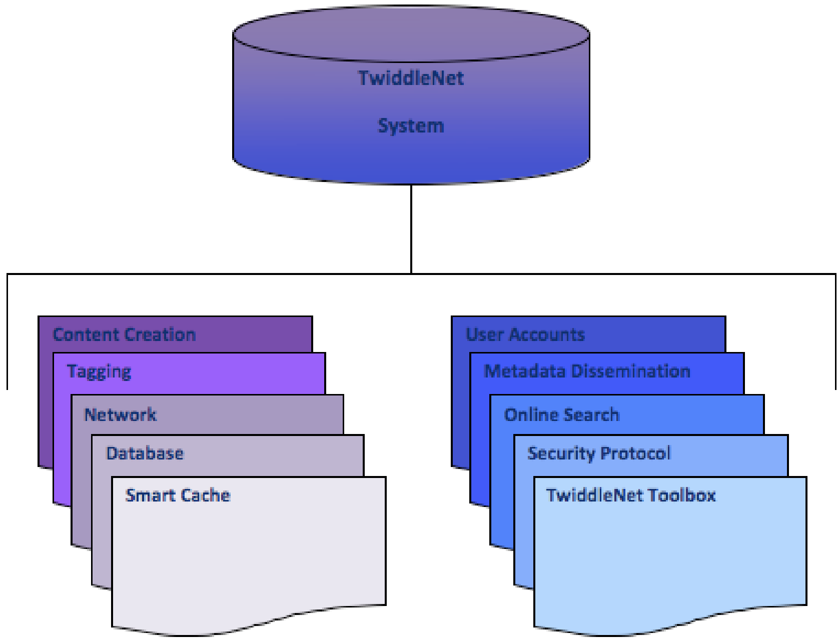

Figure 1. TwiddleNet Components

a. *Content Creation*

In the cyber realm, content can be depicted as any form of communication by the smartphone, i.e., text, photo, video, or attached file. The content is created by the user, tagged accordingly and then manually or automatically shared.

b. *Tagging*

Tagging of the content is automatic, consisting of the user/creator name, date and timestamp, file name, file size, and location (if GPS activated). Tagging of the data created acts as a record that is stored within the device's memory, as well as the database as Extensible Markup Language (XML) documents, so that distribution within the network can simultaneously occur.

c. Network

The TwiddleNet system uses WiFi or GSM, which are both Internet Protocol (IP) driven. Each piece of system hardware must have its own dedicated Internet routable IP address to properly send and receive all metadata within the WiFi cloud.

The WiFi cloud can be a local network, generated by the Network Operation Center (NOC), subcomponent of the Joint Operation Command and Control (JOCC) center, where a specific block of IP addresses are dedicated to the system. Or, the deployed TwiddleNet system can generate a private WiFi cloud in which to operate securely and autonomously. This “mobile” WiFi cloud will be thoroughly explained later in Chapter IV.

d. Database

The system infrastructure utilizes a relational database. The database stores all metadata and their tags. The smart caching is executed utilizing database tables.

e. Smart Cache

As users create their data, multiple copies of the original data is “smart cached” or stored within the database utilizing proxy servers for future retrieval. This eliminates an overload within the network by sharing the workload over several servers thereby reducing the traffic within the network so that cached copies can be utilized to service multiple user retrieval requests.

f. User Accounts

Each handheld device requires the user to log in with specific user name identifications (ID), which consist of the team member name and number, and it is then incorporated into the content tag. This allows the system translation scheme to seamlessly track all IP addresses and username ID for metadata storage, dissemination and retrieval.

g. Metadata Dissemination

The TwiddleNet system utilizes a single main network distribution device called the Portal. The Portal, which will be explained in depth in Chapter III, receives all metadata from all users and instantaneously disseminates the data to all specified recipients operating within the WiFi cloud. The actual content sharing is done by Hypertext Transfer Protocol (HTTP) to ensure compatibility between Web browsers [2].

h. Online Search

When a user or team member must search for a specific data file at a later time, it can be accessed via the portal through a Web browser based application. This allows online searching for data retrieval. Additionally, user can also retrieve files from the Portal via the handheld device or “Client” application that operates directly on the smartphone. Both alternatives allow the user to do a query text search for categories specifying

“Keyword,” “Group,” or “Author.” The result of each query must be “pulled” and downloaded by the user in order to view its content.

i. Security Protocol

In present day society, security of private information remains the utmost importance regardless of the situation. When deployed for Humanitarian Assistance Disaster Response (HADR), TwiddleNet team members will have purview of personal details that must be safeguarded within the TwiddleNet system. To accomplish this, the TwiddleNet application utilizes the security features of the smartphone. This includes incorporating a Wired Equivalent Privacy (WEP) and WiFi Protected Access with Pre-Shared Key (WPA-PSK) using the Temporal Key Integrity Protocol (TKIP) for data encryption. Additionally, for the GSM domain, the security of General Packet Radio Service (GPRS) is exploited for data transfer protocol. At this time, the current TwiddleNet application does not have the individual ability for confidentiality, integrity or authentication protocols.

j. TwiddleNet Toolbox

The TwiddleNet Toolbox consists of the specialized system component called the “Command Post,” which will be explained in detail in Chapter III.

C. FIRST ITERATION

As mentioned earlier, the genesis of TwiddleNet was accomplished by two NPS students, Christopher T. Clotfelter and Jonathon E. Towle [1]. As a premise to the TwiddleNet inception, they found that each deployed unit, i.e., medical, military, law enforcement or firefighters, had to transport several different types of photographic apparatus, communication equipment, electronic components, multiple power sources and other miscellaneous bulky items in order to obtain a rapid and detailed picture for complete situation awareness. This recognition spawned the notion that there was a significant need to streamline the process of gathering and disseminating real-time information out in the “field”; i.e., Battlefield, Disaster Field, etc.

Additionally, in those areas affected by natural and/or manmade disaster, it is more common than not to lack basic essentials crucial to a viable communication network.

Necessities, such as shelter, power, and WiFi capabilities are absent, especially in areas of natural disaster. The need for Hastily Formed Networks (HFN) [3] was clearly evidenced by such impetus from recent historical events like 9-11, Hurricane Katrina and the Indian Ocean earthquake causing the 2004 Asian Tsunami. The severity of these events, and many others like them, had proven the importance of a strong, reliable and quality network system to aide in humanitarian assistance and disaster relief efforts. The need for the ability to create a usable “on-the-fly” network to gather and share information was the catalyst for TwiddleNet.

By harnessing the mobile intelligence and power of smartphones, the first iteration of TwiddleNet was created in 2007, with Clodfelter and Towle's research focusing on the "Metadata Tagging and Data Dissemination in Mobile Device Networks." [1].

According to [1], Clodfelter and Towle exploited the supremacy of these handheld devices to instantly capture and disseminate data while commanding full control of all content, making it accessible to anyone with prior approval.

> Through a combination of automatically generated and user input metadata tag values, TwiddleNet users can locate files across participating devices. Metaphor appropriate custom tags can be added as needed to insure efficient, rich and successful file searches. Intelligent data dissemination algorithms provide context sensitive governance to the file transfer scheme. Smart dissemination reconciles device and operational states with the amount of requested data and content to send, enabling providers to meet their most pressing needs, whether that is continuing to generate content or servicing request [1].

The key development architectural scheme of TwiddleNet First Generation was a type of file sharing model or Server-Client model; this produced a successful peer-to-peer file-sharing network.[4] Within this centralized sharing network, the Portal tracks all data files and images in the database, acting as a centralized gateway to all systemic nodes, recipients and data warehouses for the shared information.

[4] Peer-to-Peer Network: A peer-to-peer computer network architecture is an architecture in which each node has the same capabilities and either node can initiate a communication session. This technology is typically used for connecting nodes via largely ad hoc connections.

1. Pros

Successful testing of First Generation TwiddleNet comprised of capturing and disseminating data to all users and recipients in the controlled environment of the NPS TwiddleNet TwiddleNet Lab. All TwiddleNet hardware components associated to the local NPS WiFi lab and to each other, creating a strong social network. Generated photos were clear, tagging of each photo was accomplished, and dissemination of the data in real-time was successful.

2. Cons

Although brilliant in concept, the First Generation TwiddleNet had fundamental issues that caused instability in network connectivity among primary TwiddleNet hardware components like the Portal and Handheld Clients (For thorough description of TwiddleNet hardware components, see Chapter III.) This continuing issue had cascading repercussions, causing handheld clients to be frequently dropped or disconnected from the network, leading to captured content never reaching intended recipients.

Additionally, the range and battery life of the basic components were less than desirable. The handheld clients could not travel very far from the portal due to the instability of the network signal. The battery life of the handheld clients were less than optimal, lasting at best 20 minutes, which I could only surmise was due to the inefficiencies/redundancies of the program, coupled with the large size of data being captured causing reduction in bandwidth which also drained battery life at an exponential rate.

D. SECOND ITERATION

The Second Generation TwiddleNet (2008) expanded the First Generation by another NPS student, Antonios Rimikis, directing his research on creating, "A Lightweight TwiddleNet Portal," [4]. This thesis involved leveraging the capabilities of,

> …mobile personal members, mobile social networks and media sharing models and developing a TwiddleNet portal running on a smartphone or PDA so that the entire TwiddleNet system can be run on handheld devices for rapid deployment in emergencies [4].

1. Pros

The ability for a single TwiddleNet Handheld Device or Client to function as the "Portal" allows for complete mobility and autonomy of the deployed system.

2. Cons

There were several concerning issues with this iteration that occurred during lab and off site deployment of the system. These issues are listed under *Operational* and *Design* categories.

a. Operational

(1) After every attempt to download an image, the system would freeze, calling for a constant reset of the

handheld device and re-association into the system. This was a serious degradation of the quick and real-time dissemination of captured data.

(2) The specific TwiddleNet Client with the dual activity of “Portal” could not continue to “gateway” any other information from other handheld devices until the error from the malfunctioning client had been corrected. This was also a major factor in degradation of the system.

(3) There was no reliable “multithreading” application available. Team members were required to wait for the completion of each sharing cycle prior to beginning a new one.

(4) Team members had to stay within close proximity of the handheld device with the dual responsibility of “Portal” to maintain connectivity to ensure data reached the portal for proper dissemination. Built-in antennas within the smartphones limited perimeter distance that the team members could loiter away from the Portal.

(5) The TwiddleNet-Client/Portal would drain battery much faster and therefore had to be continually charged or kept close to a power source, which also hampered perimeter distance of team members.

b. Design

(1) After unexpected disconnection from the system or interrupted connectivity from the portal, the team member’s collected data would not be collected and therefore storage to the database could not occur.

(2) There was a very noticeable time delay for the TwiddleNet Client/Portal database to receive any shared data. It was confirmed [by Rimikis] that the best solution to eliminate this error was to employ a dedicated server to continually run in the background.

E. THIRD ITERATION

The Third Generation TwiddleNet was created by Dirk Ableiter (2008), directing his study on the smart caching portion of the TwiddleNet program, specifically “Smart Caching for Efficient Information Sharing in Distributed Information Systems,” [2]. His thesis specifically detailed solutions to the combined issues of,

> …Consumers’ demands to share information showing the need for utilizing the mobile devices more efficiently… This thesis offers an algorithm that will conserve battery power and bandwidth, depending on demand and device capabilities… the algorithm will select the content that will most efficiently relieve these two resources and temporarily upload it to a proxy server that will serve the content on its behalf. This ‘smart’ temporary, caching will last as long as the bandwidth or battery level limits are exceeded [2].

1. Pros

a. Operational

(1) Photos and data were successfully captured and disseminated to all recipients logged onto the

TwiddleNet network. All data was successfully tagged by the creator and each recipient was able to download data at their discretion or leisure.

b. Design

(1) The TwiddleNet software application continues to support the advanced, real-time secure file sharing; each smartphone able to act as content creator and retaining the ability to directly serve user requests in a peer-to-peer fashion. TwiddleNet continues to function in a streamlined manner, allowing the user to capture and disseminate specific characterizing metadata, thereby reducing network load considerably. In other words, if the recipient actually desired to view the file, the file could then be downloaded directly onto his or her own personal handheld device without threat of system overload and possible suspension of application during file download.

(2) Conservation of battery power and bandwidth were successfully achieved, by creating an algorithm that efficiently selected sets of data that represented the actual content and temporarily storing them on a proxy server. The proxy server, serving the content on behalf of the creator, would invoke a "smart caching," [2] to store the data on the portal until recipients were ready for receipt by other team members. This smart caching would take over when the battery life of the TwiddleNet Client when the battery level reached 34%, 50%, or 67% (preset by the user). This temporary caching would continue for as long as the handheld device was signed on to the network. If the device was to be recharged and the battery level increased, all the

cached information is automatically un-cached and shared. And as a failsafe, the handheld device is automatically signed off of the network when the battery level falls below 30%. At this time, the data that was temporarily stored or "cached" on the portal was copied and delayed from further sharing until the user was logged onto the network again.

(3) Voice and musical imprints were recorded to indicate when the TwiddleNet Client is added to the TwiddleNet network, when data was sent, and when data was received. The following depicted each auditory signal:

(a) Handheld device added to TwiddleNet Network: *pre-selected music.*

(b) Data sent: *"Message sent."*

(c) Data received: "Alert received."

(4) Along with auditory signals, written verification was shown on the screen of the handheld device:

(a) Handheld device added to TwiddleNet Network: *'Signed in'* or *'Signed out.'*

(b) Data sent: *'File sent.'*

(c) Data received: 'File received.'

(5) A new graphical user interface (GUI)[5] feature was implemented to specialize in treatment during medical triage operations. This GUI allowed for additional and specific tagging of each "patient" to be added at the generation of the content. This GUI provided the freedom to

[5] GUI- Graphical User Interface. A visual way of interacting with a computer using items such as windows, icons, and menus used by most modern operating systems.

input basic patient information, i.e., name, ID number, age, gender, etc. by utilizing the touch screen keyboard or smartphone keypad and a series of pull down menus. Further specification of patient ailment(s) could be depicted by a separate screen presenting the image of a body (front and back) and by utilizing the touch screen, the user could indicate which body part(s) were injured/affected. Additional tabbed screens allowed for indication of basic treatment, i.e., bandage, splint, etc and what types of medication, if any, were administered. All information on each GUI screen could be keyed in by utilizing a combination of the touch screen keyboard, smartphone keypad and/or pull down menus. These GUI screens offered an extremely easier interaction between user and smartphone to facilitate and enhance triage operations during any humanitarian assistance/disaster relief (HA/DR) missions.

2. Cons

Although this version of the TwiddleNet application is very robust and successful on many levels, there continue to be several converse issues present.

a. Operational

When taken out into the field, the design of the hp iPAQ phones lacks the ruggedized and streamlined features that users would find helpful and sometimes necessary during HA/DR missions. These features are listed but not limited to:

(1) No ruggedized case to protect from accidental abuse.

(2) No waterproof or water resistant coating.

(3) Hands-free capability - no attachment for lanyard.

(4) Small viewing screens.

(5) Unable to use touch screen with gloved hands - must use stylus.

(6) Unable to take rapid photos - Noticeable delay.

(7) Built-in flash very small - Must have additional light source when taking photos at dusk or in the dark.

b. Design

(1) The TwiddleNet clients continue to 'freeze up' and display error messages when several photos are taken in quick succession and automatically uploaded onto the TwiddleNet Portal. At times, one or more files of captured data would not reach the portal and therefore would not be shared to awaiting recipients. The only solution to this issue was to reset the TwiddleNet Client and reconfigure back into the TwiddleNet Network.

(2) The above design flaw uncovered an additional design issue that involved the TwiddleNet Client's inability to self-correct incidences of 'multi-threading.' Specifically, when a TwiddleNet Client lost connectivity during data capture, the original IP address given to that specific TwiddleNet Client would still be 'in use.'

Therefore, upon reset of the 'frozen' TwiddleNet-Client, the server and portal were unable to associate or recognize the TwiddleNet-Client upon re-associating back into the TwiddleNet Network. This error would create an, 'open thread' that the TwiddleNet Portal would continually search for and therefore would never recognize the original TwiddleNet Client as logging back in. The solution for this flaw was based on a coding issue that had to be corrected at the programming level.

F. CHAPTER SUMMARY

The TwiddleNet system came from the realization that field work needed a more streamlined communication platform in which to capture and share data in areas where no communication infrastructure existed. Leveraging the ubiquity and power of today’s smartphones allowed the creation of an autonomous, self-contained adhoc network that allows the capturing and dissemination of field data within minutes of scene arrival.

Although the first three iterations of TwiddleNet were plagued with various operational and design issues, it has allowed sound incremental improvements that have steadily paved the way for the more stable Fourth Generation TwiddleNet.

III. DETERMINATION OF METRICS AND FEASIBILITY OF USE: FIRST THREE ITERATIONS

A. OVERVIEW OF APPLICABLE AREAS OF USE

Deploying a damage assessment system for information gathering after a disaster or in response to a DoD operation is imperative within the first 48-72 hours. Any information, data, facts or knowledge gathered during any operation is extremely time sensitive and oftentimes cumulatively relative to previous data. Distortion of these facts caused by flawed data collection or inaccurate information serves to only compound an already confusing and frequently extremely volatile and dynamic environment. And with the Normative Decision Making Theory[6] prescribing the conditions under which leaders should make decisions autocratically, or with other decision makers, it assumes the following: Individual decision are more time-effective than group decisions, subordinates are more committed to a decision if they participate in its formulation, and complex/ambiguous tasks require more information and consultation for reaching high-quality decisions. There is no space to accommodate the ill effects of faulty data collection, producing a domino effect that would easily contaminate and degrade the clarity of the knowledge gained after processing the data.

[6] Normative Decision Making Theory- Proposed by the Austrian-American sociologist Peter Blau (1918–2002), the Normative Decision Making theory prescribes the conditions under which leaders should make decisions autocratically, or in consultation with the group members, or with group members fully participating.

Competent fact gathering and dissemination in an environment based on collective reasoning is difficult when faced with barriers and challenges that accompany any natural, accidental, or willful disaster. Fact based opinion, devoid of preconceived stereotypes and bias is what is needed by a successful command and control, and this can only be achieved by specially trained first responder personnel and intelligence organizations that can gather and disseminate appropriate information to the decision makers of each military mission.

As mentioned earlier in this thesis, the primary use of the TwiddleNet application was to harness the technological power of today's smartphones and incorporate them as the primary tool for gathering and disseminating information and data during the rapid formation of 'on-the-fly' networks when deployed for humanitarian aide, disaster relief, or large urgent projects.

The ubiquitous presence of today’s smartphones are not limited to just telephonic communication, but rather they are recognized as portable personal computers (PCs) with a variety of communication capabilities. More powerful than their counterparts a decade ago, the content capture and communication capabilities have paved the way to a broad array of new services. Aside from their basic voice, text, and email capabilities, it is now possible for these mobile gadgets to provide video conferencing and streaming multimedia. Further technical advances have dramatically increased the picture quality and the multimedia message service (MMS)[7].

With these multi-media enhancements, the ability for the TwiddleNet application to be deployed for any fact gathering or triage mission utilizing commercial off-the-shelf (COTS)[8] technology makes this system not only inexpensive to obtain and maintain, but familiar and user friendly.

The TwiddleNet application was designed to support and incorporate the advanced, real-time, file sharing in a secure network environment; to be deployed and create a WiFi cloud in which to capture and disseminate valuable information within the first crucial 48-72 hours, to disseminate data for further processing by Command and Control (C2) centers and support medical agencies.

The historical destruction caused by such disasters as Hurricane Katrina is an ideal scenario in which to exhibit the positive potential of the TwiddleNet application during a humanitarian assistance or disaster relief scope. In the wake of Katrina, the communication infrastructure was completely devastated, and there remained the explicit need for communication in order to organize and synchronize relief efforts. The nature of this scenario (detailed in

[7] Multimedia Message Service- Where media messages are sent like text messages using the telephone infrastructure or by uploading the message content onto Web pages using a regular PC.

[8] COTS- commercial off-the-shelf. A term for software or hardware, generally technology or computer products, that are ready-made and available for sale, lease, or license to the general public. They are often used as alternatives to in-house developments or one-off government-funded developments.

Chapter VI: Scenario/Experimentation and Results) permitted the TwiddleNet application to deploy as a Mobile Emergency Command Post to create an autonomous WiFi network within the affected area, collecting environmental data and medical information during the triage of survivors, and further information dissemination to the C2 center.

In addition to facilitating first response and disaster relief, the TwiddleNet program can be deployed with military patrol units or surreptitious "cloak and dagger" fact gathering missions to gain photographic/video graphic data for dissemination to the C2, thus providing basic situational awareness of the target individual(s) or area. Due to the ubiquitous and international existence of the many styles of the smartphone, taking photographs and video during a covert mission is easily accomplished.

Only customized coding and implementation limit other applications for the TwiddleNet program, external to the DoD. As discussed by Ableiter [2], Social Networking capabilities to broadcast important and real-time events, i.e., the birth of a child and all pertinent details, to family and friends, without having to make a number of individual calls via a single point of contact or a pre-planned phone tree; eliminating the need to take upload photos and video to pre-existing Web sites and a later time or date. And beyond telecommunications, texts, and email, TwiddleNet offers the ability to disseminate group alerts for medical reasons, providing current and real-time updates or an expanded version of Twitter[9] where parents can follow the events in their children's lives, but within a secure and private network.

Within the commercial world, Internet based advertising has become a forward marketing tool. With the utilization of TwiddleNet, advertisers could disseminate advertising specials to consumers, sending notification of real-time sale exclusives that would persuade the consumer to purchase the sale item, or at the very least, draw them into the advertiser's retail venue, in the hopes of leading to more purchases. The ease of tracking consumer-purchasing habits and utilizing this information to customize marketing alert messages should have great appeal to today's commercial advertisers, giving the TwiddleNet program a practical use in the business world.

B. METRICS OVERVIEW

The objective of this project was to test all iterations of the TwiddleNet application after each modification, to document all system improvements and deficiencies, and to definitively confirm the validity and usefulness of the application.

There were several Measures of Performance (MOP)[10] and Measures of Effectiveness (MOE)[11] that were considered

[9] Twitter- Twitter is a privately funded startup with office in SoMA neighborhood of San Francisco, CA. Started as a side project in March of 2006, Twitter has grown into a real-time short messaging service that works over multiple networks and devices.

[10] MOP- Measure of Performance. These are expressions of a quantitative (objective) "operational" measure that is a key indicator of task accomplishment.

during the testing and analysis of all four TwiddleNet iterations. These measures were developed to test the TwiddleNet hardware and software under various types of controlled environments and scenarios, different temperatures and weather conditions, and a range of handling procedures. This section specifies how the TwiddleNet performance data was collected and analyzed throughout my thesis research. The overall assessment strategy for TwiddleNet was to evaluate the Effectiveness, Suitability, and Mission Impact of the various components under physically demanding conditions with different network configurations.

Pre-testing efforts consisted of:

1. Establishing a baseline assessment of the TwiddleNet system operating in the present environment.

2. Documenting environmental data (humidity, temperature, and foliage density), network radius and uncontrollable variables at the testing site (aka: Humanitarian Assistance scenario site).

3. Ensuring mechanical setup, Startup/Boot and correct operation of system software.

When TwiddleNet Handheld Clients were deployed, verification of data successfully captured and disseminated among team members, the TwiddleNet Command Post and all remote C2 centers was conducted. It was also confirmed that

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[11] MOE- Measure of Effectiveness. These are epressions of a qualitative (subjective) “operational” measure that is a key indicator of task accomplishment.

all TwiddleNet data and images backhauled to the Joint Operations Control Center (JOCC)[12] were continuous and clear.

Assessment of radius distance between TwiddleNet team members and the TwiddleNet Portal, TwiddleNet Portal and the TwiddleNet Command Post, and TwiddleNet team members were done to evaluate continuous data sharing and dissemination.

The final stages of testing, in consideration exclusively of TwiddleNet Fourth Generation (described in Chapter IV), consisted of the "group-sharing" feature and the ability of the TwiddleNet Handheld Clients to associate/re-associate into the network once the TwiddleNet team member has traveled outside the TwiddleNet Network radius.

This final portion also included investigating the effects of associated TwiddleNet Handheld Clients that are in 'sleep mode' (not gathering data) in 15-minute increments. Verification that the Handheld Clients continued to be associated to the network, automatically re-associated back into the network post sleep mode period, or required manually re-association.

The TwiddleNet proof of concept integrated the capturing and sharing of data between all TwiddleNet Handheld Clients, the TwiddleNet Command Post and all remote network locations via the TwiddleNet Portal distribution.

[12] JOCC- Joint Operations Control Center. A central area that boasts of rapid deployment capabilities, increased operational capability, enhanced situational awareness, and a comprehensive view of the battlespace; all designed into a high performance, low-risk system that enable decision superiority at all levels, and in all domains.

The resulting system demonstrated reception and display of TwiddleNet data at local and remote C2 centers. The main objective of the TwiddleNet testing team adhered to was to test the TwiddleNet system in various realistic scenarios and controlled lab environments for the determined performance measures to evaluate the system's utility and capability in an operational context.

Toward that end, measures and data sources address the Critical Operational Issues (COIs)[13], Objectives,[14] and MOEs/MOPs, as well as a data collection and analysis approach.

1. Overview

To evaluate the Effectiveness and Suitability of the TwiddleNet capability, testing gathered objective data from equipment readings and subjective data in the form of user feedback. The Information Architecture (IA) relied upon Data Collection spreadsheets, Computer Screen Captures, Event Logs, and data collector observations during the Technical Capability Assessments (TCA) and Operational Capability Assessments (OCA) event.

During OCA events, TwiddleNet users were asked to do the following:

a. Set up TwiddleNet system. Associate into local network using static IP addresses.

---

[13] COI- Critical Operational Issues: Phrased as a question and must be answered in order to properly evaluate operational effectiveness, and operational suitability.

[14] Objectives- Statements that break down the COI into clearly defined manageable tasks and are developed to group or organize the measures need to resolve the COI.

b. Use TwiddleNet Handheld Clients to capture data when deployed. Track data shared using "group sharing and multiple streaming” features.

c. TwiddleNet teams traveled to specified distances to verify maximum distance and range parameters for data sharing and dissemination to team members, the TwiddleNet Command Post, and the C2 centers/JOCC.

d. Evaluate TwiddleNet Handheld Clients' capability for continuous connectivity or automatic re-association into the network.

e. Review data collected through various scenarios and controlled environments.

2. Data Management and Analysis

General data management functions were distributed among the members of the TwiddleNet Team and consisted of the following:

a. Identification of data requirements.

b. Data collection.

c. Data reduction and analysis.

d. Generation of analysis products.

3. Database Development

The TwiddleNet team used standard commercial word processing, spreadsheet and database software, i.e., Microsoft Windows® Word, Access and Excel, to analyze and manage Computer and Event Log as well as data collected during the testing periods. I developed and maintained the TwiddleNet master database for data reduction and analysis.

4. Database Verification

I ensured the completeness, accuracy and quality of the data stored in the TwiddleNet database. Each member of the TwiddleNet team was responsible for reviewing their event logs and test data, annotating the notes where necessary. The data was annotated in the database at the conclusion of the day's testing events, or as soon as able. I reviewed the completed database to ensure data accuracy.

5. Database Processing and Analysis

Data was entered directly into the TwiddleNet database whenever feasible. Data collectors were trained in data entry procedures and all data were entered at the end of each day. Data entered into or transferred to electronic storage was backed up using portable media devices.

C. SYSTEM ARCHITECTURE

TwiddleNet is a program that exploits the power of today's COTS smartphones to create mobile personal servers that "serve up" real time information for sharing among awaiting recipients. This architecture employs various communication modes, i.e., WiFi, GSM/CDMA[15], GSPRS/EDGE[16], WiFi 802.11b and Bluetooth, which are standard within these smartphones to support a rapidly deployed adhoc network and a dependable data-sharing infrastructure.

The main components of the TwiddleNet architecture are the Client, the Portal, and the Command Post.

1. Client

TwiddleNet system has been utilizing the Hewlett-Packard iPAQ hw 6945 Mobile Messenger Smartphone for testing purposes (figure 2). The iPAQ hw 6945 comes standard with the following specs [6]:

a. Integrated Antenna.

b. Integrated Quad band GSM/BPRS/EDGE wireless radio with automatic band transition.

c. Integrated GPS Receiver.

d. Integrated Wi-Fi (802.11b).

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[15] GSM- (Global System for Mobile communications) is the most popular standard for mobile phones in the world. GSM is used by over 3 billion people across more that 212 countries. Its ubiquity makes international roaming very common, enabling subscribers to use their phones all over the world. GSM differs from its predecessors in that both signaling and speech channels are digital, and thus is considered a second-generation (2G) mobile phone system. CDMA- (Code division multiple access) is a channel access method utilized by various radio communication technologies. It employs spread-spectrum technology and a special coding scheme (each transmitter is assigned a code) to allow multiple users to be multiplexed over the same physical channel.

[16] GPRS- (General packet radio service) is a packet oriented mobile data service available to users of the 2G cellular communication systems GSM, as well as in the 3G systems. In 2G systems, GPRS provides data rates of 56-114 Kbit/s. EDGE- (Enhanced Data rates for GSM Evolution) is a backward-compatible digital mobile phone technology that allows improved data transmission rates, as an extension on top of standard GSM. EDGE is considered a #g radio technology and is part of International Telecommunications Union's 3G definition.

e. Integrated Bluetooth 1.2 wireless technology.

f. Intel PXA270 Processor 416 MHz.

g. Integrated HP Photosmart 1.3 MP Camera.

h. Integrated alphanumeric keyboard.

i. Integrated miniSD slot (memory only).

j. Removable/rechargeable 1200 mAh 3.7 Volt, Lithium-ion battery.

k. Microsoft Windows® Mobile 5.0 for Pocket PC, Phone Edition, with Messaging and Security Feature Pack.

l. Mobile versions of Microsoft Windows® Office software include (Word, Excel, PowerPoint, and Internet Explorer).

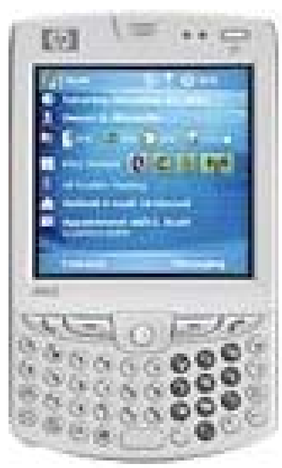

Figure 2. iPAQ hw 6945 Mobile Messenger Smartphone.

Each TwiddleNet team member is given their own HP iPAQ hw 6945 which utilizes the Microsoft Windows® Mobile program to run the TwiddleNet application, coordinating communication between all the components. Upon logging into the TwiddleNet network, each handheld device is assigned a specific and unique IP address from the TwiddleNet DHCP server, automatically giving the content creator a specific tag. Alternately, the TwiddleNet client can also be assigned a specific IP address that can be hard coded into the smartphone. This is usually done when the local adhoc network has assigned a specific block of IP addresses for the exclusive use by the TwiddleNet team. All metadata files are instantaneously tagged with the content creator's specific tag and IP address.

After logging into the system, the client has three utilities:

a. Allowing the TwiddleNet member to instantly create metadata, capture images and photos (utilizing the 1.3 MP camera) and disseminate to the entire team.

b. Alerting the portal of immediate availability.

c. Offering a basic interface for the team member to accept and download any metadata files created by other team members.

All TwiddleNet team members are deployed with the TwiddleNet Portal (Figure 3) to gather and disseminate data, functioning as either personal content servers or personal content requesters. This role exchange is automatic, easily accomplished and transparent to the team member.

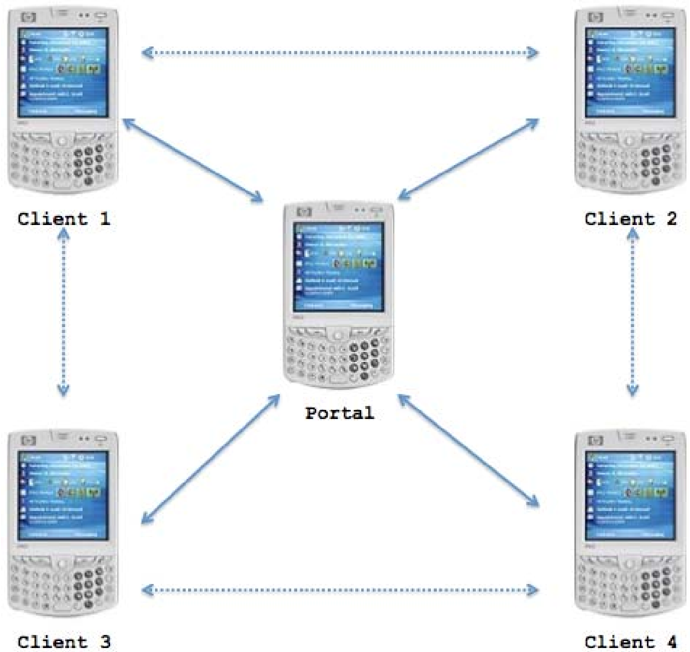

Figure 3. Basic TwiddleNet Infrastructure w/handheld acting as the Portal.

2. Portal

For all iterations of the TwiddleNet system, the OQO Ultra Mobile PC (Figure 4) has been utilized as the main Portal component, and the HP iPAQ hw 6945 smartphone as an alternate option. The OQO Ultra Mobile PC is a fully functional Windows PC small enough to fit in your pocket, yet powerful enough to rival a regular laptop. It comes standard with the following specifications [7]:

a. OS: Microsoft Windows® XP Professional.

b. 1GHz Transmeta Crusoe Processor.

c. 30GB hard drive (shock-mounted).

d. 512MB DDR RAM.

e. 800 x 480 W-VGA 5" transflective display (indoor/outdoor readable).

f. 3D accelerated graphics with 8MB of video RAM.

g. 802.11b wireless.

h. Bluetooth wireless.

i. 4-pin FireWire (1394)/USB 2.0.

j. 3.5mm stereo headphone jack/microphone/speaker.

k. Battery life up to three hours.

l. Weight: 14 ounces.

m. Accessories: Universal power supply, docking cable, desktop docking stand.

n. For input/navigation: Thumb keyboard with TrackStick, mouse buttons, and thumbwheel.

Figure 4. a. OQO Ultra Mobile PC. b. OQO Ultra Mobile PC w/Docking Station.

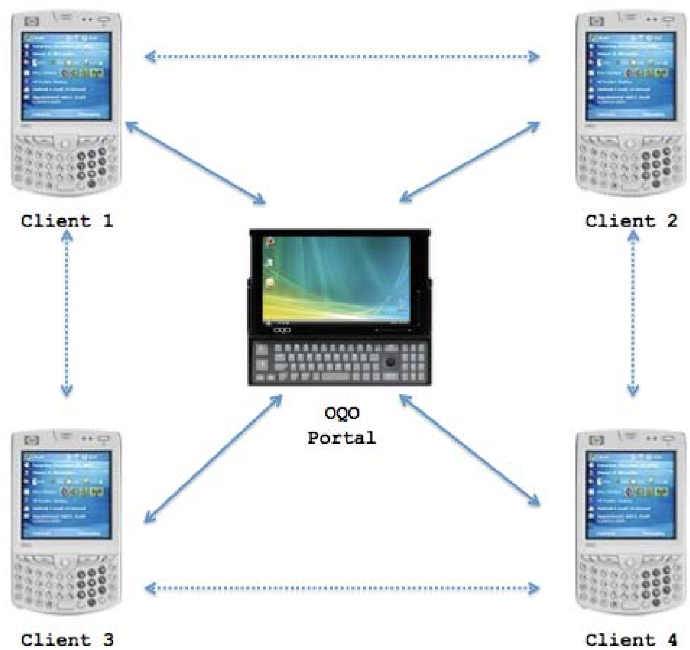

Figure 5. Basic TwiddleNet Infrastructure w/OQO as Portal.

The TwiddleNet Portal (shown in Figure 5) acts as a type of gateway for the TwiddleNet network, monitoring when clients log in and out of the system, receiving and storing all metadata and content generated by all the users, and disseminating/"pushing" to all team members instantaneously or when a user "pulls" the information at a later time. The Portal also stores all "tagging" information for all TwiddleNet Clients logged into the system, tracking all IP addresses currently in use.

3. Command Post

Currently, the TwiddleNet Command Post program functions on a Linux laptop, but can be run on any Windows laptop or desktop computer. When specified by the individual Clients, the Command Post will receive all metadata alerts and can also retrieve or "pull" all content files that are being temporarily stored by the Portal. It then displays all downloaded content on the Web display page in sequential order of receipt. Each data file is automatically tagged by the specific content creator and any other specific information, inputted by the user upon data creation, is also shown. The Command Post also has the ability to manually update each data file, at any time, with additional information beneath each displayed image.

The Command Post is typically left at the JOCC or C2 location to generate increased information superiority. Through Network Centric Warfare[17] [8] utilities, the deployed users can "push" data from the affected area to mission commanders to achieve shared awareness and a level of synchronization for all decision-makers.

Alternatively, the Command Post can also be deployed with the TwiddleNet Clients and Portal to the affected area and be linked to the JOCC/C2 via backhaul link communications or SATCOM (satellite communications)[18]. Regardless of whether the Command Post is deployed or not, any computer system operating within the same WiFi network as the TwiddleNet system can access all data and photos on

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[17] Network Centric Warfare- A term developed to describe the way the DoD would like to organize and fight in the Information Age. The former CNO, ADM Jay Johnson, has called it "a fundamental shift from platform-centric warfare." In essence, NCW translates information superiority into combat power by effectively linking knowledgeable entities in the battlespace.

[18] SATCOM- Satellite Communications. A family of communications satellites originally developed and operated by RCA American Communications (RCA Americom)[11]. An artificial satellite that is used to help telecommunication by reflecting or relaying signals back from space and back down to Earth. It is the most powerful form of radio and it can cover far more distance and wider areas than other radios. It can also communicate with words, pictures and other forms of information.

the Command Post database. Opening a Web browser on the specified computer and typing in the IP address of the TwiddleNet Command Post laptop will accomplish this. Figure 6 is a screen capture of the TwiddleNet Command Post display. Note that basic information of the photo is displayed just underneath the captured image.

Figure 6. TwiddleNet Command Center screen display.

D. NEWLY DESIGNED DATABASE

The newly designed Portal Database was created by LCDR Todd Glidden [4] and is featured in the 4th iteration and fully described in Chapter IV. Critical to the TwiddleNet program design, the Portal Database warehouses system data, to include user identification, device and component data, IP addresses, temporarily stored metadata, and group membership classifications. Because of continued errors with multithreading, group sharing, and associated issues with network congestion, Glidden recognized the need to upgrade the Portal Database design.

Glidden re-constructed the database design, utilizing formal database design methods, to include Entity-Relationship (E-R) and Relational modeling. The major elements of the new database are [9]:

1. Portal User Table. This contains user identification that is critical for verification when the user signs in and for linking users to groups (to track group membership). This element is fundamental to the user-partitioning feature introduced in the 4th iteration.

2. Belongs To Table. Routes users to groups by linking a unique user identifier listed in the Portal Users Table with a unique group identifier stored in the Groups Table. This tells the Portal which users belong to which groups so that alerts and data dissemination can be properly sent to the specified group(s).

3. Groups Table. This links the user with his specific handheld device. This is accomplished by linking a unique identifier for the user from the Portal Users Table with a device identifier in the Devices Table. The IP address of the user's device is stored and can be retrieved by the Portal from the Devices Table.

4. Devices Table. Stores critical identification information, to include IP addresses, for all handheld devices signed onto the TwiddleNet system.

5. Content Info Table. Stores the metadata associated with shared data/information.

6. Special Tags Table. This is designated to store situation-specific data, as established by the system administrators and mission planners deploying the TwiddleNet system. Currently, this table stores medical triage data as detailed in [2].

The database management system used for this upgrade was MySQL. As specified by Glidden, the decision to use MySQL was based on the following:

1. It is an open-source and freely available.

2. It allows for easy administration through the use of tools such as phpMyAdmin[19] [10].

As detailed in the System Operation (Chapter IV) the MySQL must be activated during the sign-in process of the Portal to begin the gateway functions.

[19] PhpMyAdmin- An open source tool written in PHP intended to handle the administration of MySQL over the World Wide Web. It can perform various tasks such as creating, modifying or deleting databases, tables, fields or rows; executing SQL statements; or managing users and permissions.

IV. FOURTH ITERATION

A. OVERVIEW OF OLD AND NEW TWIDDLENET OPERATION

In previous iterations of TwiddleNet, the users or content creators were all members of the same group or team; users were defined and delineated only by their identification tags. However, in the fourth iteration or Fourth Generation TwiddleNet, Glidden expanded the TwiddleNet virtualization operation to include a group partitioning application and content privacy. Through his research and coding development, Glidden presents in his thesis, *"Privacy for Mobile Networks via Network Virtualization,"*[9]:

> The use of mobile devices and mobile networks to [define and expand] a network virtualization technique in order to provide content privacy protection. This allows TwiddleNet users to share content on a per-group basis among virtual networks of user groups. It was found that this virtualization technique successfully provided content privacy protection from the threat of a casual observer [9].

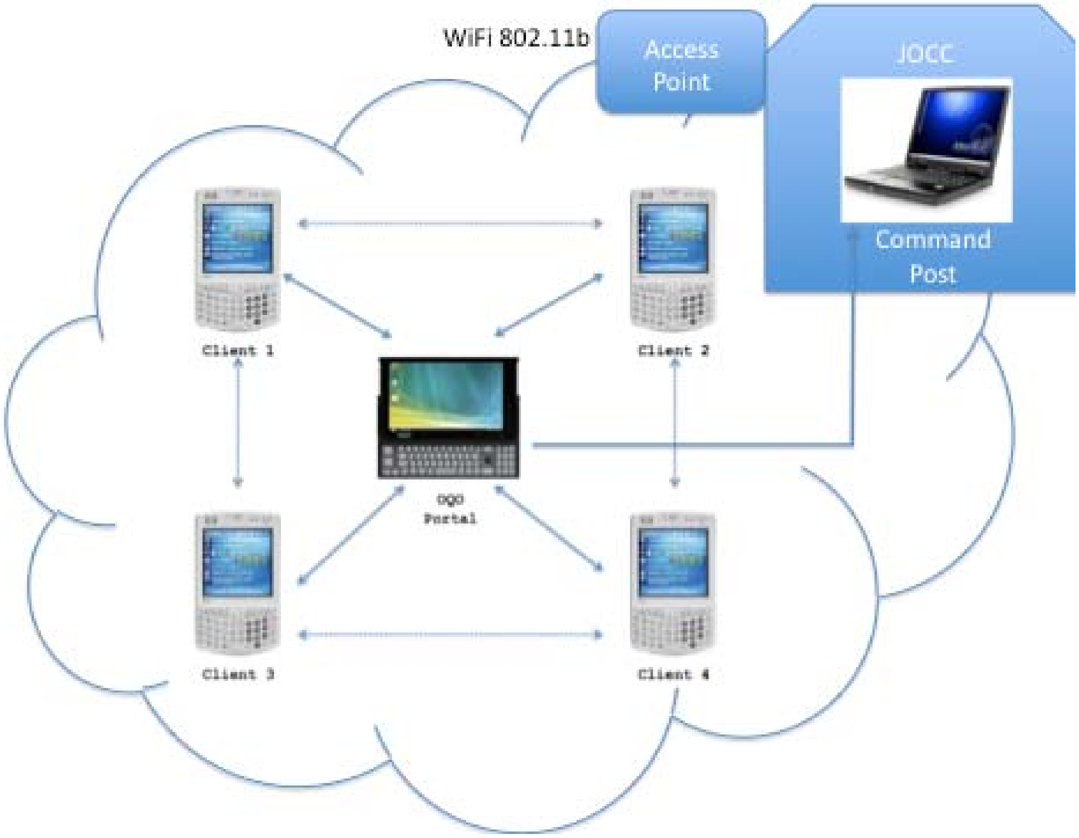

Figure 7. Old TwiddleNet Operation.

Figure 7 illustrates the old operational layout of TwiddleNet Generation(s) 1-3, utilizing the local adhoc WiFi 802.11b network generated by the mission C2/JOCC. As shown here, all TwiddleNet clients are functioning within one group construct, sharing all information among all team members and the Command Post via the OQO Portal. (Note: When operating within the C2 adhoc WiFi network, pre-ordained static IP addresses are set aside for the explicit use of the TwiddleNet Team(s). All IP addresses are hard coded into each component, with the Command Post and Portal always programmed with the first two addresses.)

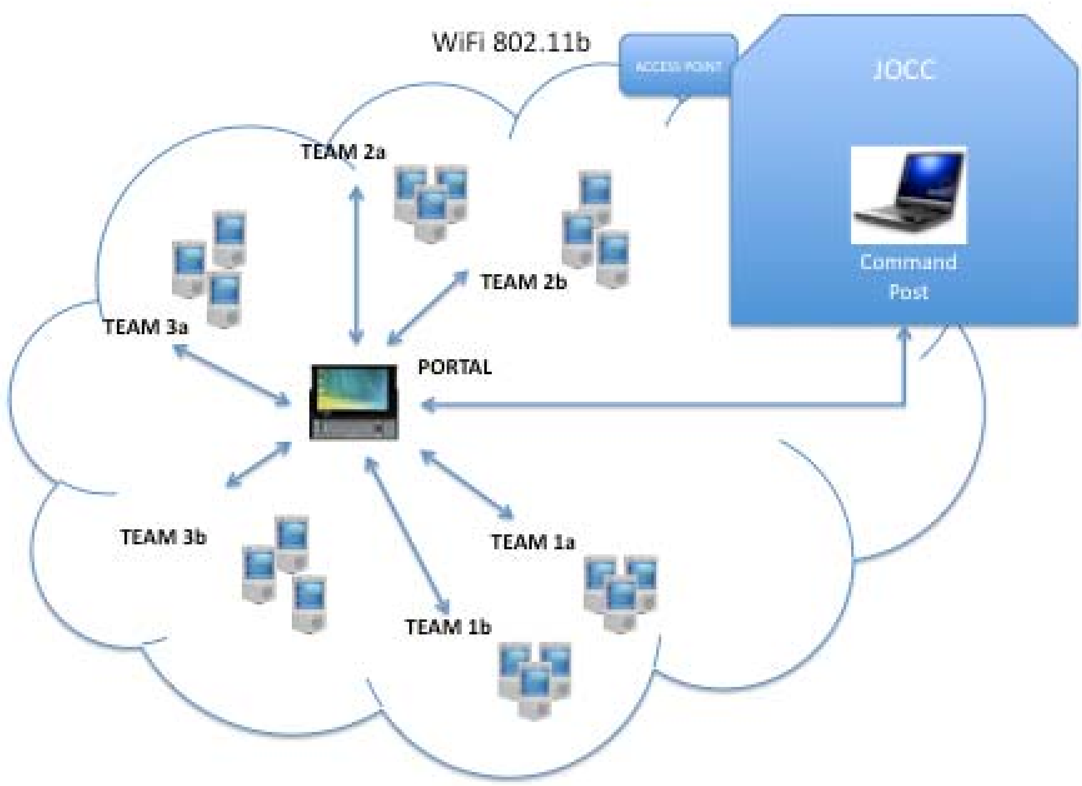

Figure 8. New TwiddleNet System Operation w/Group Partitioning.

As Figure 8 illustrates, each content creator is a member of a specific group: Team 1(a/b), 2(a/b), or 3(a/b). This is chosen upon sign in of that particular handheld client. Team members can specify which team(s) will be a recipient(s) of their metadata to include the Command Post. For example, if Team 1a member(s) desire to share content only with members of Team 3b and the Command Post, these recipients would be chosen during the sign in process. When Team 1a members create their metadata, it is sent to the Portal, which sends alerts and shares the data with only Team 3b members and the Command Post; the other Teams are not alerted and therefore will not have access to the information. After receiving an alert, the recipient(s) may download the file instantaneously or at a later time.

Furthermore, if a Team 1a user(s) desires to change recipients during exploration and data collection, this can be accomplished by returning to the "Recipient Options" screen without requiring signing out and/or signing in. The upgrade in the Portal Database allows this streamlined group partitioning to function smoothly and seamlessly, the user simply making use of a basic GUI (Figure 9), selecting the box of specified recipient(s) with the stylus and touch screen. The default box is always the team that the user belongs to. For added convenience, there are also two other boxes labeled "All" or "None."

Within the user-partitioning feature, teams are explicitly labeled as:

1. Team 1(a)(b)- Medics.
2. Team 2(a)(b)- Fire Fighters.
3. Team 3(a)(b)- Police.
4. Command Post.

Figure 9. TwiddleNet Client Recipient Options screen.

There is no limit to the number of handheld clients/users within each team.

The second noteworthy advance in Fourth Generation TwiddleNet is the content privacy stemming from the user-partitioning feature. With the ability to specify which team members can receive the information, safeguards the information collected. For example, members within the Medics Team will be collecting personal patient information, i.e., Name, age, identification/SS number, etc. that does not need to be shared with members of the Fire Fighter and Police team. Concurrently, Medic team members would not find it necessary to know of any illegal proceedings, i.e., looting/burglary, going on in a different part of the affected area.

The third noteworthy advance within Fourth Generation TwiddleNet is the advent of the TwiddleNet Gateway component. The TwiddleNet Gateway was a piece of new interfacing software, placed on a separate Dell laptop, which allowed content sharing and receipt from other external sources, i.e., the Command Post. The Gateway could also "push" data and information to all the TwiddleNet users, utilizing the same group-partitioning feature, specifying who would receive the information. The TwiddleNet Gateway could be as close as within the mission JOCC/C2, or as far away as a different city, state, or country. In these instances, connectivity would have to be generated by SATCOM.

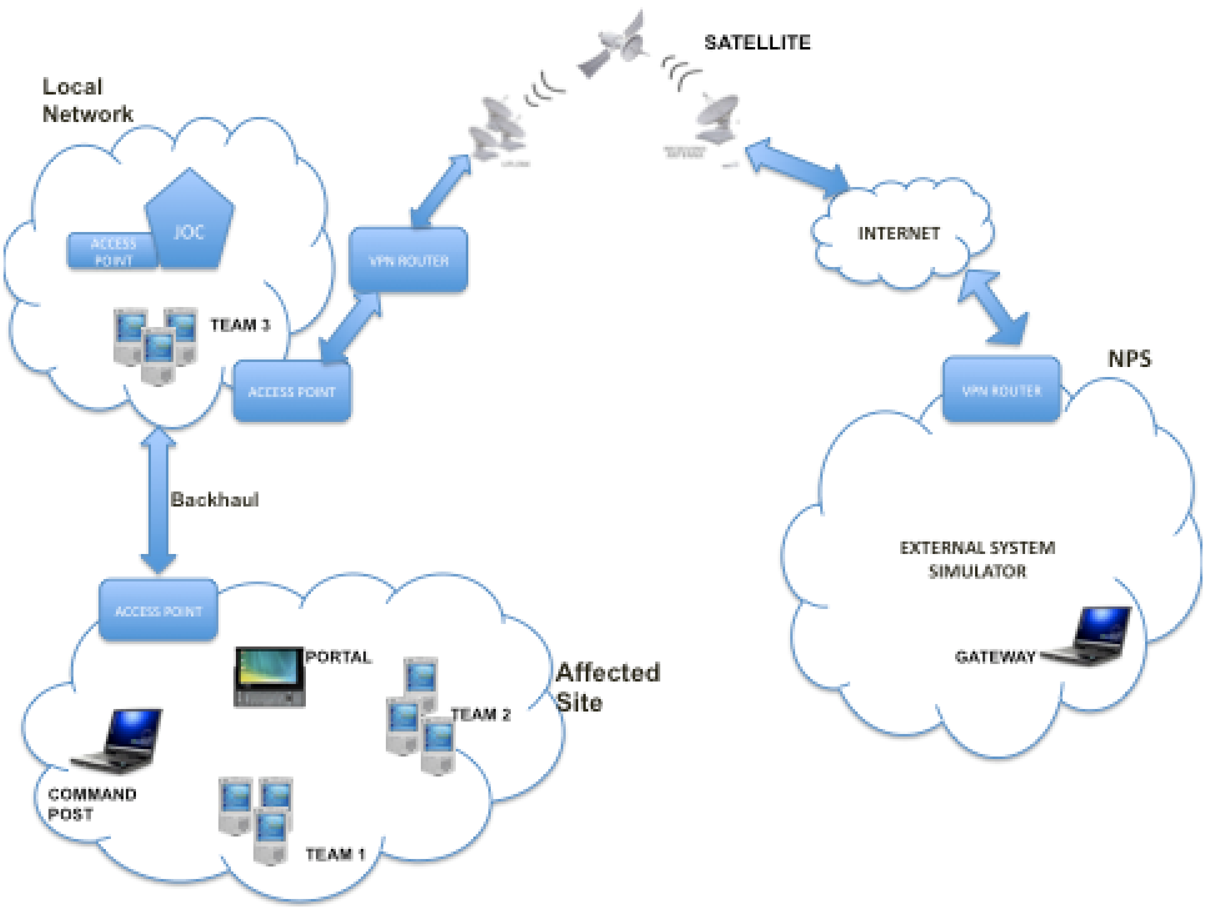

Figure 10. Advanced TwiddleNet Layout w/SATCOM and Gateway.

Figure 6 shows the advanced layout of the TwiddleNet system during a complex operation. Within several WiFi adhoc networks generated by several access points, several TwiddleNet teams are deployed into the affected area(s) (i.e., Thailand, New Orleans), generating and gathering data that is sent to the deployed TwiddleNet Portal, which in turn, sends alerts to the other team members and to the command post. Each JOCC and external Gateway site (i.e., NPS- Naval Postgraduate School) can access all data sent to and from the command post via connections generated by backhaul links and SATCOM, providing far-reaching capabilities anywhere in the world.

1. Implementation Tools

The software programming language used for all the TwiddleNet iterations was C#. The TwiddleNet Portal code is based on the .NET 2.0 Framework intended for PC integration. The TwiddleNet Client coding is the Pocket PC application, supported by the .NET 2.0 Compact Framework, intended for use by devices running Windows Mobile 5 operating system (OS).

Microsoft Windows® Visual Studio 2005 Integrated Development Environment® was employed during the TwiddleNet program development. This was due to the ease of use, translation and integration for the C# language. Furthermore, Visual Studio was an excellent integration tool with the Pocket PC Software Development Kit, providing a powerful standard for the Client development, offering additional tools for easy code transference and device testing.

As mentioned earlier, MySQL Database Management System was utilized to accommodate the TwiddleNet Portal database (refer to Chapter III, pg. 46). This management system incorporated the XAMPP[20] cross-platform Web server for ease of implementation and testing. It also allowed the use of phpMyAdmin for a convenient interface for the MySQL database, resulting in a simplified management tool for the TwiddleNet Portal database.

2. Fly Away Kit

With all iterations of TwiddleNet, the consistent theme was the ability to be quickly deployed and easily established with efficient ease. With this in mind, the creation of the TwiddleNet Fly Away Kit (FLAK) was accomplished and perfected. With the simple addition of a COTS Cisco Aironet Wireless Access Point (Figure 11), the TwiddleNet System became completely autonomous; capable of deploying, creating a private and encrypted WiFi network, and gathering and disseminating information within 20 minutes of on-site arrival (thoroughly explained in Chapter VI: Experimentation and Results). The TwiddleNet Access Point transmits 802.11a/b/g, and is designated as the TwiddleNet Mobile Network.

[20] XAMPP- A free and open source cross-platform Web server package, consisting primarily of the Apache HTTP Server, MySQL, and also translates code written in the PHP and Perl program languages. It is designed to allow programmers to test work on their own computers without Internet access.

Figure 11. Cisco Aironet Wireless Access Point.

The TwiddleNet FLAK, encased in a single, medium sized, portable Pelican Case Product[21], stores and protects the following TwiddleNet hardware components:

1. 10 Clients (w/desktop charging stations and power cords).

2. 1 OQO Ultra Mobile PC (w/desktop charging station and power cord).

3. 1 Linux laptop and power cord (Command Post).

4. 1 Dell laptop and power cord (Gateway).

5. 1 Cisco Wireless Access Point (w/power cord and 4' CAT 5 cable).

6. 4 8-outlet surge protectors/power strips.

The Pelican Case (pictured in Figure 12) is tactical, logistical and durable, airline and Transportation Security Administration (TSA) approved, making this an ideal

[21] Pelican Case Products- Pelican Products is a global manufacturer of advanced lighting system, rugged protector cases and shipping containers

transport container. All components are 110v/220v compatible, allowing deployment to other countries possible.

Figure 12. Pelican Case w/Customizing Padding.

B. NEW TWIDDLENET SYSTEM OPERATION AND SETUP PROCEDURES

This section provides a step-by-step guide for the complete preparation and implementation of the TwiddleNet System. With this complete and detailed guide, training of any new user could be accomplished within one hour.

1. Create the WiFi Cloud

a. Plug in and power up the Linux laptop/Command Post.

b. Connect the TwiddleNet Cisco Wireless Access Point with the blue CAT 5 cable.

c. Connect the TwiddleNet Access Point power cord into the surge protector/power strip.

2. Setup of the Portal

a. Plug in and power up the OQO Mobile PC.

b. Ensure that it is connected to the TwiddleNet Mobile Network and is assigned the following IP address: 192.168.1.3.

c. Scroll to the bottom icon “XAMP.”

(1) Start “XAMP.”

d. Double click on the TwiddleNetServer icon.

(1) A command window pops up and states that the server is running.

(2) If this does not occur, verify WiFi connection and then double click the TwiddleNetServer icon.

3. Command Post Setup

a. Verify that the Portal (OQO or client) IP Address, within the TwiddleNet Mobile Network, is listed as: 196.168.1.3.

b. Double click on the Command Post icon.

(1) The Command Post screen will display.

(2) Press the "Start" button at the bottom of the screen *only once.*

(3) The screen should display "Waiting for alerts.”

c. Open the Internet Explorer browser and type, "www.localhost.8080" in the browser line (should be in the history pull down menu).

(1) The displayed page is probably an old page, so once you have taken a test photo, the screen will refresh automatically. If not, press the "refresh" button.

4. Setup of the Client

NOTE: Prior to the start of any mobile device, ensure that all other service components are running properly.

a. Power up handheld device (power button located on top right of smartphone).

b. Verify association to correct network.

(1) Press the WiFi "iPAQ wireless" tab.

Figure 13. WiFi iPAQ wireless tab screen.

(2) Press "View WiFi Networks.”

Figure 14. iPAQ Screen "View WiFi Networks.”

(3) Click once on the specific network name.

Figure 15.   iPAQ Configure Wireless Networks screen.

c.   Adding a New Network on the iPAQ wireless.

(1) Return to the iPAQ wireless screen.

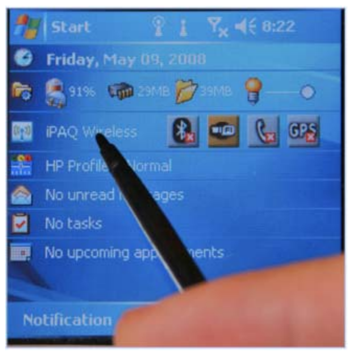

Figure 16.   iPAQ wireless tab screen.

(2) Press "View WiFi Networks.”

Figure 17.   iPAQ "View WiFi Networks" screen.

(3) Click once on "Add New..."

Figure 18. iPAQ Configure Wireless Networks "Add New..." screen.

(4) Type in the new Name, then click on the tab in the center of the screen that reads "Network Key.”

Figure 19. iPAQ "Configure Wireless Network" screen w/Network Key tab.

(5) Select the appropriate Authentication and Encryption.

Figure 20. iPAQ "Configure Network Authentication" screen.

(6) NOTE: For "TwiddleNet" and "TwiddleNet Mobile" networks, the Authentication is "Open" and the Encryption is "WEP.” Ensure that the tickbox underneath is not selected.

(a) Enter the network key "927e31e9b8" into the field.

(b) Click "OK" on the top right of the screen.

(c) If it does not connect, try re-entering the key, turn WiFi off and on again.

Figure 21. iPAQ "Configure Network Authentication" screen.

d. If the DHCP (mechanism that automatically assigns IP addresses) is provided by the network, the Client should now receive an IP address. Verify by going to the iPAQ Wireless screen (Figure 22).

Figure 22. iPAQ Wireless screen.

(1) NOTE: For Advanced Users: If you know that you do not have DHCP service, get an IP address, network mask, default Gateway and DNS address from the Network Administrator.

e. Return to the main screen (Figure 23). Turn on the WiFi by pressing the second grey button from the left only ONCE.

Figure 23. iPAQ Main screen.

(1) The WiFi button will turn green once it has associated to the network with an IP address.

(2) NOTE: If it does not turn green- check WiFi connection again.

(3) NOTE: If it still does not turn green- verify that IP address (manual/automatic) is correct for the specific network being used.

f. When connected to the network, return to the "Start menu" (Figure 24).

Figure 24. iPAQ Start menu.

g. Scroll to "Program Files.”

h. Start TwiddleNet program. (Skip directly to "Start TwiddleNet").

i. To manually enter a Fixed IP-Address:

(1) Go directly to the iPAQ Wireless screen and select the "View WiFi Networks" (Figure 25).

Figure 25. iPAQ Wireless screen.

(2) On the bottom of the screen, select the "Network Adapter" tab (Figure 26).

Figure 26. iPAQ Configure Wireless screen.

(3) Click on the WiFi Adapter (Figure 27).

Figure 27. iPAQ Configure Network Adapter screen.

(4) Select "Use Specific IP Address," and enter the IP-Address, Subnet Mask and Gateway. Then click on the "Name Servers" tab (Figure 28).

Figure 28. iPAQ Wi-Fi Wireless Adapter screen.

(5) Enter the DNS Server IP-Address and click the OK button at the top right corner of the screen (Figure 29).

Figure 29. iPAQ Wi-Fi Wireless Adapter screen.

(6) Read the text box (Figure 30): It means that you have to turn the WiFi off and on.

(7) Click “OK.”

Figure 30.   iPAQ Configure Network Adapters screen.

(8) Click "OK" until you are back at the main screen (Figure 31), then turn WiFi Button off and on.

Figure 31.   iPAQ Main Screen.

C. STARTING TWIDDLENET

Once all the TwiddleNet components are connected/associated to the selected WiFi network, TwiddleNet can be started.

1. Once the "WiFi" button is green on the main menu screen, the User will select "Start." From the drop down menu, the User will then select "Programs."

2. From there, "File Explorer" will be chosen. Then the user must click on the down arrow to produce a drop-down menu.

3. Selecting "My Device," another drop-down menu appears, allowing the User to choose "Program Files," and then, "TwiddleNet_application."

4. This selection leads to another drop-down menu, where "TwiddleNetCapp" is chosen to begin the TwiddleNet application. Figure 32 illustrates each step.

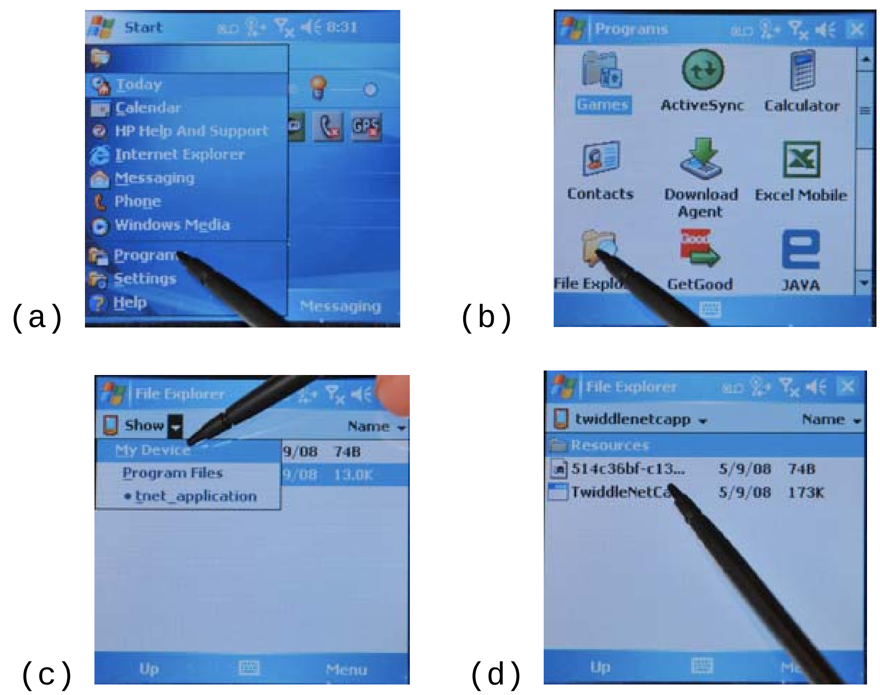

Figure 32. TwiddleNet Startup.

1. Client *Sign-in*

Each Client must "Sign-in" to be recognized by the Portal and the TwiddleNet program. At the "SignInForm" screen (Figure 33), the User will enter the name of his/her team, i.e., Team 1a, Team 1b, Team 2a, Team 2b, Team 4a, Team4b. The password, associated to whatever team the user is assigned to, is then typed in, i.e., team1, team2, team3, and team4. The Password is case specific, utilizing all lower case.

Figure 33. SignInForm screen.

When the user has successfully signed the Client into the TwiddleNet application, the German National Anthem can be heard. This indicates that the Client has successfully signed into the Portal, the Portal has validated the Client, and written verification will also show on the Portal screen. When validation occurs, the Portal will store the IP address of the Client and also update the address to reflect the current user. (Incidentally, this is one way in which the Portal tracks the IP addresses of all active Clients).

At this point, the Portal retrieves the group the user, "belongs to," in addition to all the groups utilizing TwiddleNet at that time. This information is then provided to each Client so that the Recipients can be selected for data sharing.

2. Recipient Selection

After the sign in process has been successfully completed and verified via Portal verification and the completion of the German National Anthem, the User then chooses the Recipients. This is accomplished by selecting the box(es) of the appropriate Recipients (Figure 8): Medics, Fire Fighters, Police, Command Post, All, and None.

D. SIGNING OFF FROM TWIDDLENET

When the User completes testing and usage, the Client *must* undergo "Sign Off" procedures from the TwiddleNet application.

1. Always delete all *shared/received photos* from the present testing session. This will keep the memory clear and battery life optimal.

2. Always "Quit" TwiddleNet application on the Client.

3. Always disconnect Client form the associated network by selecting the WiFi icon on the iPAQ Main Menu screen. (Ensure the WiFi icon is brown in color). This will also save battery life when the Client is in "Sleep Mode."

4. Press the power button on the Client/Handheld Device to enter the smartphone in "Sleep Mode."

5. Verify written verification of Client *“Sign Off”* on the Portal screen.

6. Command Post *Sign Off*

    a. Quit the TwiddleNet program.

b. Verify the Command Post, "Sign Off," on the Portal.

c. Power down the TwiddleNet laptop.

7. Portal *Sign Off*

a. "Stop" XAMP application.

b. Quit the TwiddleNet program.

c. Power down the OQO component.

E. RESETTING TWIDDLENET

1. Client *Freeze*

If the Client "freezes up," wait to see if the Client *self corrects.* The handheld device is sometimes slow, but will finish each application step one at a time. If the User is certain that the Client will not move any further, press the *Reset* button located at the bottom of the handheld device (Figure 34). This is called a, "soft reset." After this occurs, start the TwiddleNet application normally. (NOTE: Turning off the handheld device will not work).

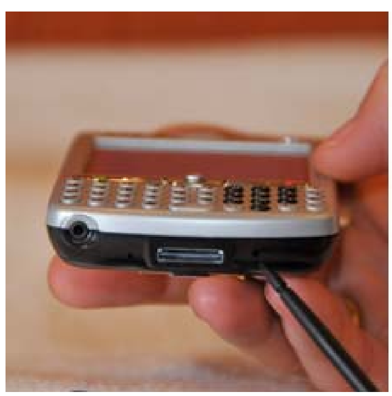

Figure 34. iPAQ Client Reset button.

2. Application *Reset*

To reset the whole application, delete the, "TwiddleNet," file (Figure 35). That will delete all the user settings and shared content. This should only be done if nothing else works. (NOTE: Never delete the file that starts the TwiddleNet application).

Figure 35. TwiddleNet Application Reset- TwiddleNet File deletion.

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V. TESTING DESCRIPTION: ITERATIONS 1-4

A. CONTROLLED LAB TESTING

All iterations were tested at the Naval Postgraduate School TwiddleNet Network Lab (Figure 36). At this location, a dedicated access point generated a stand-alone WiFi network, code named TwiddleNet. The access point, Command Post and Portal maintained dedicated IP address, while the Clients were issued dynamic IP addresses via the DHCP server.

Additionally, presentations and demonstrations were conducted in this lab for potential research sponsors and general interest.

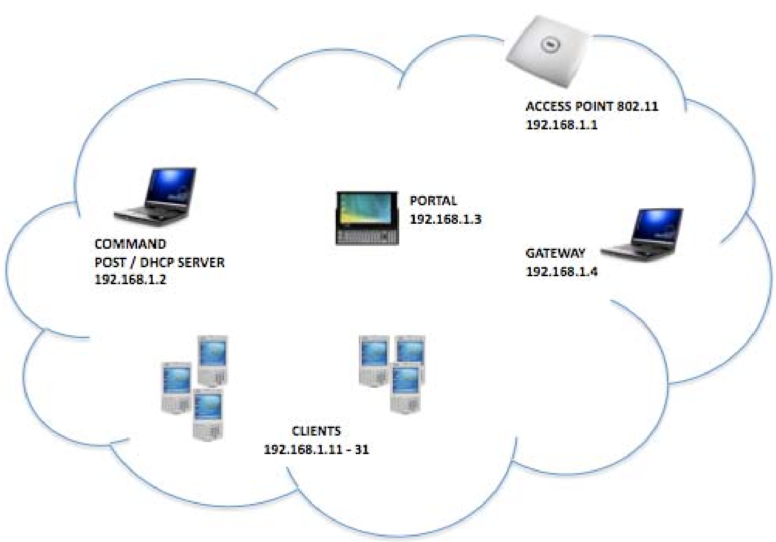

Figure 36. Naval Postgraduate School TwiddleNet Network Testing Lab layout.

B. TESTING SCENARIOS

To test the TwiddleNet System outside of the NPS TwiddleNet Network Lab, TwiddleNet was incorporated into the NPS Cooperative Operations and Applied Science & Technology Studies (COASTS) in the pursuit of specific scenario testing of all TwiddleNet iterations. Since 2005, COASTS has been a collaborative program with the Royal Thai Armed Forces, providing a venue to test promising technologies. The specific leveraging aspects of COASTS are:

- To forge relationships between key organizations and individuals within the Royal Thai Armed Forces and US DoD.
- To gain valuable experience through technical demonstrations and field experimentation (particularly in Southeast Asia and Thailand).
- To document processes for technology assessments,
- To provide continued support by NPS Students and the ONR[22] Program (38 Reserve Officer).

The main purpose of COASTS was to experiment with candidate technologies in a field environment to:

- Confirm technology maturity and CONOPS[23].
- Assess candidate technologies and provide

operational feedback to the science and technology community.

- Provide a venue for NPS faculty research and

Student thesis projects.

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[22] ONR - Office of Naval Research. Coordinates, executes and promotes the science and technology programs of the United States Navy and Marine Corps. [15]

[23] CONOPS - Concept of Operations. Generally developed from a specific concept and is a description of how a set of system capabilities can be utilized to reach desired objectives or a specific conclusion for a certain scenario.

The COASTS Field Experiment (FEX) Series was designed to ensure technology readiness prior to insertion into specific scenarios and exercises. Organized FEXs were conducted at Camp Roberts, CA in preparation of integrated FEXs with the Royal Thai Armed Forces in Thailand. The following were the major field exercises and scenarios that integrated TwiddleNet for testing and assessment.

1. Camp Roberts FEX III 2008

This specific FEX presented a mock real-world environment that imitated the natural disaster of the 2004 Boxing Day Tsunami[24] incorporated First Generation TwiddleNet, created by Clotfelter and Towle. The TwiddleNet system utilized the COASTS local network created by the Network Operating Center (NOC). TwiddleNet was utilized by the COASTS Mobile Emergency Command Post (MECP) and dispatched (on cue) to the affected site via scripted scenario. The TwiddleNet team was deployed via the MECP First Responder vehicle to the affected site where data was collected and disseminated among the team members and pushed to the JOCC. This scripted scenario (Appendix A) was a rehearsal in preparation for FEX IV as a joint exercise with the Royal Thai Armed Forces. Overall, TwiddleNet functionality was a success. Pros, cons, and major results of this testing were presented in Chapter II and synopsis of the after action report (AAR) is provided in Chapter VI.

[24] 2004 Boxing Day Tsunami- The 2004 Indian Ocean earthquake was an undersea megathrust earthquake that occurred at 00:58:53 UTC on December 26, 2004, with an epicenter off the west coast of Sumatra, Indonesia. The quake is known as the Sumatra-Andaman earthquake. This tsunami is all known as: 2004 Indian Ocean Tsunami, Asian Tsunami, Indonesian Tsunami, and Boxing Day Tsunami.[14]

2. Thailand FEX IV 2008

After test results were garnered from FEX III 2008, Ableiter and Rimikis made appropriate modifications for Second Generation TwiddleNet. The TwiddleNet team then traveled to Parachuap, Thailand, for a joint exercise with the Royal Thai Armed Forces on the Rayong Air Base. The same Boxing Day Tsunami scenario was performed, incorporating the TwiddleNet team as first responders for triage tasking and information dissemination. Pros, cons and major system results were listed in Chapter II and a synopsis of the AAR is provided in Chapter VI.

3. Thailand FEX V 2008

FEX V was again located at Parachuap, Thailand at the Rayong Air Base. Third Generation TwiddleNet, created by Ableiter, was incorporated into the same Boxing Day Tsunami scenario, deployed as first responders to the affected site, code named Humanitarian Assistance (HA) site. Royal Thai soldiers were utilized as, "victims" to enhance functionality of the TwiddleNet system.

The TwiddleNet team utilized the local COASTS WiFi network generated by the NOC. This WiFi network was expanded by a backhaul communication link, provided by Western Data Communications Technology, to the HA site. This allowed an expansion of the COASTS NOC WiFi network spanning several miles and across an ocean bay. Information, data, and photos were pushed from the HA site to the JOCC utilizing this communication link.

Power was generated from portable batteries, which supplied electricity for all TwiddleNet hardware components and the backhaul antenna. All TwiddleNet components, Backhaul Communications components, medical triage equipment and TwiddleNet medical triage personnel were transported to the HA site in the MECP transportation vehicle.

Overall, the TwiddleNet system performance was a success. Pros, cons, and major results of this testing were presented in Chapter II and a synopsis of the AAR is provided in Chapter VI. Several onsite photos are provided in Figures 37-41.

Figure 37. Humanitarian Assistance site.

Figure 38. HA site w/Western Data Communications Technology Backhaul Communication Link.

Figure 39. Royal Thai soldiers portraying injured survivors.

Figure 40. TwiddleNet onsite HA setup.

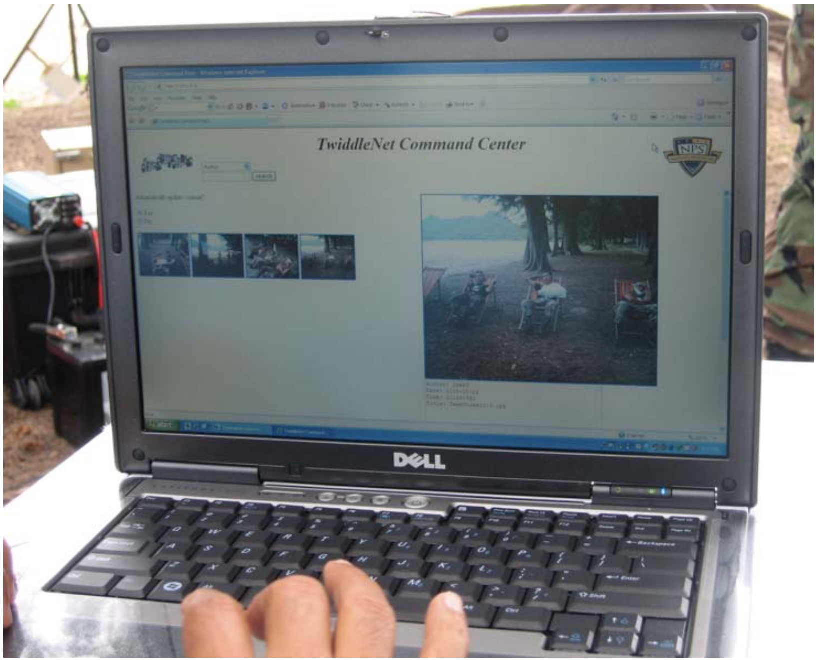

Figure 41. TwiddleNet onsite Command Post.

4. Camp Roberts FEX III 2009

The results collected from FEX V 2008 allowed Glidden to modify and stabilize Third Generation TwiddleNet, leading to the most reliable iteration, Fourth Generation TwiddleNet. Although FEX III 2009 did not incorporate a specific scenario, it allowed a venue in which to test TwiddleNet with other emerging technologies, i.e., the B-GAN satellite for backhaul communication link to the JOCC. This B-GAN was also utilized to push/pull information and data between Camp Roberts and the NPS TwiddleNet Network Lab via the TwiddleNet Gateway computer.

Overall, the TwiddleNet system performance was a success. Pros, cons and major results were presented in Chapter II and a synopsis of the AAR is provided in Chapter VI.

5. Thailand FEX IV 2009

FEX IV 2009 was located at Jomtien, Thailand, on the Satahip Naval Base. Although there was no specific scenario being executed, there were opportunities for continued testing in the same environment and several opportunities for TwiddleNet presentation and demonstration to the Royal Thai Armed Forces other VIPs.

Overall, the TwiddleNet system performance was a success. A detailed assessment plan was provided in Chapter III and results are provided in Chapter VI.

VI. EXPERIMENTATION RESULTS

A. TEST DATA

For each COASTS FEX, a TwiddleNet Test Plan (Appendix B) was submitted to the COASTS NPS Team Lead to ensure all data was captured in a complete and organized fashion. Daily situation reports (SITREPS) were submitted each day during all COASTS FEXs.

Raw testing data for the first three iterations of TwiddleNet was gathered and documented on TwiddleNet Test Data Sheets (Appendix C).

B. AFTER ACTION REPORTS (AAR)

AARs for all TwiddleNet testing that occurred during each COASTS FEX were submitted to the COASTS NPS Team Lead.

1. Camp Roberts FEX III 2008

a. Results

Overall, testing was successful. All MOEs/MOPs were accomplished.

Portal functions were reliable and all images captured by Clients were disseminated to all TwiddleNet Team Members and the JOCC.

Note: Connectivity was intermittent by Handheld Clients, but all captured images and metadata were stored on creator's handheld device.

b. AAR (Appendix D)

2. Thailand FEX IV 2008

a. Results

Positive feedback was received for integration of Royal Thai Armed Forces in the TwiddleNet Humanitarian Assistance Boxing Day Scenario.

All TwiddleNet components were successful in associating to the local COASTS WiFi network.

Unfortunately, issues arose with heat and humidity affecting the TwiddleNet Handheld devices. All TwiddleNet Clients were successful in capturing, storing images and metadata for approximately 10 minutes before the system froze.

b. AAR (Appendix E)

3. Thailand FEX V 2008

a. Results

Overall, testing and scenario execution was successful. Major achievements:

(1) TwiddleNet Medical Triage Team were successful in gathering and disseminating patient data in real-time among team members, the TwiddleNet Command Post, and the JOCC.

(2) System functions for all TwiddleNet components occurred as expected, exhibiting system reliability.

(3) All remote C2 centers received real-time data, raising situational awareness of the Humanitarian Assistance site.

(4) Backhaul antenna provided by Western Data Communications Technology was successful in linking TwiddleNet WiFi Network at the HA site to the COASTS WiFi network located several miles away.

b. AAR (Appendix F)

4. Camp Roberts FEX III 2009

a. Results

Due to severe time constraints for the TwiddleNet researchers, limited testing was conducted during this COASTS FEX. Major achievements included:

(1) Successful testing of Fourth Generation TwiddleNet conducted. System stability and reliability confirmed.

(2) Successful testing of TwiddleNet Gateway function. Information and data was shared between the TwiddleNet Gateway located at the NPS TwiddleNet Network Lab and the TwiddleNet Command Post located at Camp Roberts, CA. COASTS JOCC was also able to view data passed from the TwiddleNet Gateway.

5. Thailand FEX IV 2009

a. Results

As stated earlier, there was no COASTS FEX scenario executed. FEX IV 2009 provided a venue for TwiddleNet presentations and demonstrations to be given to Royal Thai Military Forces and other military VIPs. As a result, great interest was generated among the Royal Thai Military Forces, requesting market availability for the TwiddleNet Application. It also provided the opportunity for a comprehensive assessment to be conducted for Fourth Generation TwiddleNet.

Additionally, successful testing was conducted for the following:

(1) Multithreading of Clients.

(2) Group Sharing function for individual TwiddleNet Teams.

(3) Automatic re-association of Clients into the COASTS Local WiFi Network after travel outside of WiFi radius.

(4) Automatic re-association of Clients when awaken from, “sleep mode.”

C. PROS AND CONS OF FOURTH GENERATION TWIDDLENET

As stated earlier, COASTS FEX IV 2009 provided a venue for the comprehensive assessment of Fourth Generation TwiddleNet. A narrative of the comprehensive assessment plan was provided in Chapter III within the Metrics Overview section. The complete Fourth Generation TwiddleNet Assessment Plan, to include testing results, is located in Appendix G.

1. Pros

a. Fourth Generation TwiddleNet exhibited an overall 95% performance reliability resulting in the most consistent and dependable iteration.

b. Consistent data dissemination during multi-threading option.

c. Consistent data dissemination during group sharing function.

d. Consistent reliability of Clients ability to re-associate into local WiFi network after, “sleep mode,” and when re-entering WiFi cloud radius.

(1) All captured data was stored in Client files until re-association into WiFi network at which time data was sent to Portal for further dissemination.

2. Cons

a. There were no major technical issues; however, there were several minor observations. They are as follows:

(1) TwiddleNet Clients have only an 80% ruggedization percentage. HP iPAQ Smartphones are several years old and need to be replaced with more a robust model.

(2) There was an intermittent 20% degradation with the operating distance. This was not completely understood and therefore, future testing should be conducted in this area.

VII. SUMMARY AND CONCLUSIONS

A. APPLICATION TO THE DOD

As mentioned earlier in this thesis, the main objective of TwiddleNet was to use a smartphone based networking application for first responder triaging during humanitarian assistance/disaster relief missions. However, future applications of TwiddleNet can be expanded to enhance other DoD missions.

For example, current research for Fifth Generation TwiddleNet, conducted by LT Chey Hock Sim, Singapore Navy, and LT Hong-Aik Lee, Singapore Navy, proposes a new architecture to expand system capabilities to allow cross networking for information sharing [15]. This could potentially lead to an expansion of the triage area, allowing several first responder teams to deploy to several disaster areas with continuous capabilities for data collection and dissemination. This would undoubtedly lead to greater situational awareness for all C2 centers and major decision makers.

TwiddleNet could also be integrated with other emerging technologies, i.e., Unmanned Aerial Vehicles to surreptitiously gather environmental data at a greater distance to gain an overall assessment of the target area.

Further exploration into the realm of covert information gathering, TwiddleNet could be utilized to secretly capture and distribute photos and images of specific targets/persons of interest during confidential missions, to distribute false images to mislead an adversary or for tactical deception.

B. FUTURE WORK

This work represents potential improvement in the overall TwiddleNet system. There is great opportunity to increase overall range, the number of deployed teams, network security, and the triage graphical user interface. These suggestions are strictly from a user perspective as my expertise does not encompass programming skills. Some thoughts are listed below.

1. Network Linking

As mentioned earlier, Fifth Generation TwiddleNet is exploring the possibilities of expanding the range and number of deployed teams by linking two or more networks together. This would increase the deployable range and allow sharing between two or more networks, greatly enhancing an overall situational awareness of the affected area(s). This research could possibly include utilizing satellite technology for more far-reaching capabilities, and to receive data and instruction from other medical facilities in networks around the world.

2. System Security

Currently, the only encryption available to TwiddleNet is WEP encryption, which leaves vulnerability gaps within the system. To enhance encryption, TwiddleNet could be incorporated with emerging technologies, such as GHOSTNet- a secure and anonymous Virtual Private Network (VPN) service. Coupling Ethernet tunneling and proxy services to provide users safe and anonymous Internet access, GHOSTNet utilizes TSL (SSL) protocol with AES-256 encryption to secure the network along with PKI certificates and HMAC protection from replay attacks and UDP flooding [17].

3. Triage Graphical User Interface (GUI)

Currently the GUI for the triage tasking is very basic and rudimentary. A more explicit graphical form with more drop-down menus could be generated. This would save time for the user/triage team member by eliminating the need to *"type out"* notes regarding injuries and current medical condition.

For this improvement, a dedicated and experienced programming engineer would have to be employed.

C. CONCLUSIONS

This work successfully tested and evaluated all iterations of the TwiddleNet Networking application. We conclude that this system is extremely worthwhile and beneficial, with a strong foothold in the realm of adhoc networks for first responder medical triaging. TwiddleNet has been extremely successful in the field for gathering and disseminating information, images, and data in real time. This is an unmistakable advantage in gaining situation awareness for all command and control centers and for all decision makers.

With continuous incremental improvements in reliability and stability, Fourth Generation TwiddleNet has quickly become an extremely powerful and valuable system, with unlimited possibilities of future developments, DoD integration, and commercial network optimization. It is my hope that a dedicated (and funded) R&D program will bring TwiddleNet into marketable productization in the very near future.

APPENDIX A. EXCERPT COASTS TSUNAMI SCENARIO SCRIPT

COASTS FEX IV TwiddleNet Scenario Script

Background

An unexpected tropical storm racing across the Gulf of Thailand has led to a category 4 Typhoon causing flash flooding in the small coastal town of Rayong, Thailand. Sixty minutes following the conclusion of the typhoon, the COASTS MECP is deployed to assess damages and set up triage area. Additionally, a Military Operation in Urban Terrain (MOUT) within the main city of Rayong, Thailand (to seize and secure key combatant targets) has been delayed due to the typhoon. MUOT to take place approximately sixty minutes following the completion of the typhoon, in order to maintain the element of surprise.

Humanitarian Assistance Phase-1 (in black font)

00:00 **Phase 1 COMEX**. Sixty minutes after the conclusion of the tropical typhoon, MECP is deployed to disaster area in order to assess damages and set up triage area. Concurrently, Military Operations in Urban Terrain (MOUT) and clearance and capture of enemy personnel from Urban Built-Up Areas (UBUA) by the COASTS Combined Task Force (CTF) has commenced. Thirty minutes after the completion of the MOUT, the MECP is deployed to set up triage area. The CTF-COASTS liaison to COASTS team requests assistance to survey the scope of the injuries / casualties, search and rescue for injured survivors and initiate initial medical triage efforts for two locations. After an additional hour of coordination and crisis planning, COASTS has determined how best to support this request and coordinate the support with the host-nation. Time elapsed since MOUT completed +02:00.

00:01 JOCC Directs AU-23 Mosquitos to be launched from Wing-XX and dispatched to disaster region and MOUT area.

00:01 **JOCC Director** (Ch-1): "Airboss, JOCC, launch alert AU-23 to FLOOD region."
Airboss (Ch-1): "Roger, launch alert AU-23"

00:01+30 **Airboss** (VHF): "Mosquito 01, Airboss, launch and depart to FLOOD area, report on ground routes and extent of damage"
Mosquito 01 (VHF): "Roger, launch and depart"

00:02+30 **Airboss** (VHF): "Mosquito 02, Airboss, launch and depart to MOUT area, report on ground routes and extent of damage"
Mosquito 02 (VHF): "Roger, launch and depart"

00:03 **Mosquito 01** (VHF-tower): "Rayong Tower, Mosquito 01 ready for takeoff, turnout to northwest and departure to south."
Tower (VHF): Provides necessary clearance.

00:10 **Mosquito 02** (VHF-tower): "Rayong Tower, Mosquito 02 ready for takeoff, turnout to northwest and departure to south."
Tower (VHF): Provides necessary clearance.

00:02 JOCC Directs two Mobile Emergency Command Post (MECP) Teams to depart Joint Operation Command Center (JOCC) for MOUT zone.

00:02 **JOCC Director** (Ch-1): "MECP-A, JOCC, depart for flood zone"
MECP-A (Ch-1): "Roger, departing"

00:03 **JOCC Director** (Ch-1): "MECP-B, JOCC, depart for MOUT zone"
MECP-B (Ch-1): "Roger, departing"

00:04 **JOCC Director** (VOIP): "PCF, JOCC, transit to offshore of flood zone"
PCF (VOIP): "Roger, departing"

00:20 AU-23 arrives over FLOOD area, video provided to COASTS JOCC and to remote sites via COASTS network. PCF arrives in MOUT area.

00:20 **Mosquito 01** (VHF): "JOCC, Mosquito 01, I am over FLOOD zone now. Many resort buildings have sustained significant damage. Large number of bodies in and around beach landscape. Will transmit video."
JOCC Director (VHF): "Mosquito 01, JOCC, understand significant damage, loss of life and injured POWs / noncombatants, waiting on video"

00:25 **Mosquito 02** (VHF): "JOCC, Mosquito 02, I am over MOUT area now. Fighting in Fortified Objectives (FOFO) has sustained significant damage. Large number of bodies in and around urban landscape. Will transmit video."
JOCC Director (VHF): "Mosquito 02, JOCC, understand significant damage, loss of life and injured POWs / noncombatants, waiting on video"

00:20+30 **PCF** (VOIP): "JOCC, PCF, I am offshore from FLOOD zone. I confirm report, significant damage and bodies awash in water."
JOCC Director (VOIP): "PCF, JOCC, thank you for confirmation"

00:20 Timeline compression. 60 minutes simulated elapsed. After short survey of disaster areas, routes are determined into the area for disaster relief teams and military extraction teams. JOCC relays this information to the inbound MECP Teams. Both AU-23s use loiter capability to remain over both areas and provide continued SA and support. Both MECP teams arrive in disaster areas within seconds of each other.

00:20 **MECP** (SATCOM): "JOCC, MECP-A, we have arrived in FLOOD zone, initiating setup, will launch UAV, standby for video, TwiddleNet, and reporting"
JOCC Director (SATCOM): "Roger MECP-A, JOCC standing by"

00:22 **MECP** (SATCOM): "JOCC, MECP-B, we have arrived in MOUT area, initiating setup, will launch UAV, standby for video, TwiddleNet, and reporting"
JOCC Director (SATCOM): "Roger MECP-B, JOCC standing by

00:50 MECP teams set up complete (including TwiddleNet) and initial reports data-linked back via satellite / B-GAN to COASTS JOCC. Mini-UAV supports MECP, reporting on damage and possible survivors to surrounding area through aerial surveillance.

00:50 **MECP-A** (SATCOM): "JOCC, MECP-A, you should be receiving video, UAV video, and TwiddleNet. FLOOD region has suffered significant damage to all buildings; many survivors have sustained extensive injuries. This is a major disaster zone. Inland road structure is intact, but refugees are flooding the network. Local communications are down. Medical assistance and housing needs have priority."

JOCC Director (SATCOM): "MECP-A, JOCC, Roger, will pass your information to higher, continue observation and reporting"

00:54 **MECP-B**(SATCOM): "JOCC, MECP-B, you should be receiving video, UAV video, and TwiddleNet. MOUT area has suffered significant damage to several buildings; enemy POWs and noncombatant survivors have sustained extensive injuries. This is a major disaster zone. Inland road structure is intact, but refugees are flooding the network. Local communications are down. Medical assistance and housing needs have priority."
JOCC Director (SATCOM): "MECP-B, JOCC, Roger, will pass your information to higher, continue observation and reporting"

00:56 Reports on damage/scope of disaster relayed from COASTS JOCC to host-nation Command Center and local NGO headquarters in capital.

00:58 **JOCC Director** (Phone): Makes contact with host-nation command center(s) and local NGO headquarters to confirm receipt of information

00:60 Phase 1 FINEX: Mini-UAV recovers. MECP teams return to base.

APPENDIX B. EXAMPLE TWIDDLENET TEST PLAN

From: Lillian A. Abuan, LCDR, SC, USN
Dirk Ableiter, LT, GNY
COASTS

To: Jim Ehlert
COASTS

Subj: FTX – III TWIDDLE NET EVALUATION TEST PLAN

1. Overall and daily objectives:
    a. Scenario: Deploy a Mobile Emergency Command Post (MECP), utilizing small, light weight handhelds that supports backhaul communications from a disaster zone to UCLA telemedicine center.
    b. Utilize TwiddleNet for function related medical triage tasking during mass casualty / humanitarian ops.
    c. Utilize TwiddleNet to test and evaluate the effectiveness of all equipment associated for capturing and disbursing triage images; smooth information flow.
    d. Utilize TwiddleNet to create an infrastructure that denotes a hierarchy for scenario evaluation, info gathering, and distribution in order to analyze optimal solution; completely evaluate situation through captures images for highest optimal solutions.
    e. Create a step by step decision process to best equip first responders when preparing to dispatch aid.
2. Time blocks expected for testing. Within those time blocks:
    a. Personnel required:
        1) Dirk Albeiter, Lillian Abuan
        2) 3 person team to use peripheral TwiddleNet equipment to test functionality during a mass casualty / humanitarian triage scenario.
    b. Equipment required
        1) TwiddleNet Portal ink OQO (small computer)
        2) 5 Handheld devices running TwiddleNet
        3) One laptop running the Command Post (Dirk's computer)
        4) Everything using the given network
    c. "Hard" and "Soft" timelines
        1) Wednesday: Setting up of TwiddleNet 1000 – 1700
            a. Drill down for TwiddleNet set up and equipment use
        2) Thursday:
            a. Setting up Mobile Command Post
            b. Identifying Command and Control Hierarchy
            c. Conduct testing from 0900 – 1700
                - SET 1: Randomly take pictures with five devices simultaneously in automatic mode (take pic → rest → ??) Test "multithreading" (30 min, Team: 5)
                - SET 2: Same as one but enter different tags with keyboard (30 min, Team: 5)
                - SET 3: TBD. Limited device testing.
3. Measures of Effectiveness / Measures of Performance for equipment you're testing
    a. Team ability to take photos and disburse to PORTAL and MECP
    b. Data sharing capabilities: speed, size of data
4. Independent, dependent, and controlled variables (respectively: What you're changing each time, what you're measuring, and what stays the same for each run)
5. Data required from other COASTS members (i.e. APRS GPS location, METOC info)
    a. Network info
6. Topology diagram / sketch / description of where you are setting up equipment, if applicable
    a. TBD. The Triage Team will disburse within WiFi radius.
7. Matrix for data collection – what parameters you intend to capture as independent variable changes.
    a. Data gathering limits: battery life of handhelds, area of operation, weather conditions, equipment efficiency

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APPENDIX C. TWIDDLENET TEST DATA SHEET

A	B	C	D	E	F	G	H	I	J	K	L	M
DATE / HANDHELD USED	Connection of WiFi Detected	IP Detection by ALL Hardware	Proxy Server Detection by ALL Hardware	Connection Established between Handheld Devices / Data Shared (Y/N)	Multithreading Capability by Handhelds (Y/N)	Viewable Data seen by All Handhelds (Y/N)	Remote Video viewable by Portal / Mobile Command Post	Remote Video viewable by JOCC	Ability to Remotely View Pictorial Data by Command Post Server	Ability to UPDATE Pictorial data w/ written comments	INMARSAT Connection Detected by ALL Hardware (Y/N)	Data shared by ALL Hardware using INMARSAT

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APPENDIX D. TWIDDLENET COASTS FEX III 2008 AAR

18 February 2008

From: Lillian A. Abuan, LCDR, SC, USN
Dirk Ableiter, LT, GNY
COASTS

To: Jim Ehlert
COASTS

Subj: FEX III TWIDDLE NET HUMANITARIAN ASSISTANCE SCENARIO TEST AND EVALUATION RESULTS

1. Overall objectives:
   a. Scenario: Deploy a Mobile Emergency Command Post (MECP), utilizing small, light weight handhelds that supports backhaul communications from a disaster zone to the TOC CP for orientation and distribution to the UCLA telemedicine center.
   b. Utilize TwiddleNet for function related medical triage tasking during mass casualty / humanitarian ops.
   c. Utilize TwiddleNet to test and evaluate the effectiveness of all equipment associated for capturing and disbursing triage images; smooth information flow.
   d. Utilize TwiddleNet to create an infrastructure that denotes a hierarchy for scenario evaluation, info gathering, and distribution in order to analyze optimal solution; completely evaluate situation through captures images for highest optimal solutions.
   e. Create a step by step decision process to best equip first responders when preparing to dispatch aid.
2. TwiddleNet Equipment tested
   a. TwiddleNet Portal Link OQO (mobile computer located in the MECP vehicle)
   b. 4 Handheld devices running TwiddleNet
   c. TwiddleNet Laptop located at the TOC
   d. Available WiFi network
3. Measures of Effectiveness / Measures of Performance
   a. TOC CP (laptop): **SUCCESSFUL**
   -- received images and data
   --Note: "REFRESH" button needed to be pressed for receipt
   b. MECP (OQO): **SUCCESSFUL**
   -- received images and data
      a) NOTE: currently receiving same images / data as TOC
      b) FUTURE: need more independence; HIERARCHY
         (1) Handhelds (2) MECP/OQO (3) TOC (4) TELEMED UCLA
   -- PORTAL function **SUCCESSFUL**
   c. INTERNAL SYSTEM APPLICATION: **SUCCESSFUL**
   -- Handhelds able to take photos.
      a) NOTE: delay between photos longer than expected
   -- Multithreading: **SUCCESSFUL**
      a) Handhelds able to take photos simultaneously and send to Portal for distribution

d. CONNECTIVITY: **INTERMITTENT**

a) No indication of non-connectivity by handhelds
--images stored on handhelds until connectivity reestablished
--NOTE: Dirk creating and implementing new program for real-time indication of connectivity; debugging system

b) Intermittent connectivity occurring when MECP vehicle in low areas surrounded by hills

4. Future Testing
   a. Implementing "ready-made" triage forms for on-site medical evaluation
   b. MECP / TOC Hierarchy established; independent receipt of information
   c. GHOSTNet for Handhelds

APPENDIX E. TWIDDLENET COASTS FEX IV 2008 AAR

26 March 2008

From: Lillian A. Abuan
LCDR SC USN
COASTS

To: Jim Ehlert
Program Manager
COASTS

Via: Juan Gutierrez
LCDR USN
COASTS

Subj: COASTS FEX IV 2008 THAILAND HUMANITARIAN ASSISTANCE AND TEST/EVALUATION OF TWIDDLENET AFTER ACTION REPORT (AAR)

1. Major Achievements

- Humanitarian Scenario
    a) Positive feedback for integration of Thai counterparts for participation in disaster drill
    b) Positive feedback for integration of Corpsmen reservists
    c) Positive feedback for location of HA site

- TwiddleNet system
    a) Positive test for associating to mobile access points, i.e., JOCC_AP, HU_AP
    b) TwiddleNet JOCC Command Post Server positive test for associating and recognition of TwiddleNet Portal
    c) TwiddleNet Handheld devices / clients positive test for image & data gathering and sharing w/ other devices / clients via TwiddleNet Portal
    d) TwiddleNet Handheld devices / clients positive test for storage of all image & data

2. Major Problems

- TwiddleNet Handheld devices / clients severely affected by heat and humidity

a) All devices able to capture, store, share images for appx. 10 mins before freezing
b) Constant resetting of device required
c) Overheating occurring consistently within 5 minutes of introduction into environment.
d) Cooling no longer alleviated issue
e) Program unable to run on handhelds
f) Error messages occurring within 5 minutes of running program
g) Issue still unresolved. Suspect program will have to be reloaded

- TwiddleNet system unable to be tested early due to lack of Network

- Poor comms during scenario
  a) Very difficult to hear / understand JOCC team leader
  b) No comms with PC for extraction portion of scenario

3. Lessons Learned

- Problem:
  a) HP iPAQs are not robust enough to handle environment
  b) Hand held radios not strong enough for distance from the JOCC

- Description:
  a) Cooling system not enough for heat & humidity

- Lessons learned:
  a) Antennas on handhelds not strong enough to break through RF interference causing unit to constantly work harder / hotter
  b) Processor cooling system not strong enough for environment

- Solution:
  a) Acquire better handheld clients

APPENDIX F. TWIDDLENET COASTS FEX V 2008 AAR

Dr. Singh / LCDR Abuan
AAR

Major Achievements:

1) TwiddleNet enabled the Medial Triage Team to share patient data and medical triage information in real-time among the team members, as well as, with the Mobile Emergency Command Post at the Humanitarian Assistant site and the Joint Operations Command Center.

   a) All iPAQ handheld devices able to take and receive photos: Multithreading Successful.
   b) All handhelds able to receive audio alerts from other handhelds
   c) Portal (OQO) able to visually display each specific handheld upon association / disassociation to Portal.
   d) Portal (OQO) displayed written alert upon receipt / distribution of each image taken by all handhelds.

2) Remote command centers were able to get complete situational awareness of the Humanitarian Assistant site in real-time with pictures and annotated text.

   a) Photos tagged with personal PT info
   b) Photos tagged with medical triage information

3) Network cloud established to cover 300 yd. radius at Humanitarian Assistance site using Western Data Communications technology: SUCCESSFUL

   a) TwiddleNet associated w/ Western Data Communications Case: SUCCESSFUI

   b) Redline 802.16 backhaul established for connection of Humanitarian Assistance site and JOCC: SUCCESSFUL

Major Problems (indicate if unresolved)

1) NTR

Lessons learned:

1) **Problem**: Association of phones with open WiFi networks
   Description: TwiddleNet continually attempting to associate with multiple open WiFi networks and dropping the designated WiFi network (HU_AP)
   Solution: Stabilize software application to maintain connection with dedicated WiFi network (HU_AP)

2) **Problem**: Unstable cameras
   Description: Cameras on iPAQ hardware slow, unable to take multiple photos in quick succession, would continually freeze during use of application.
   Solution: Acquire stronger and faster hardware, which is now available

3) **Problem**: Requires phone pre-configuration for static IP addresses
Description: Unable to automatically associate TwiddleNet hardware to dedicated WiFi network. Must continually input static IP addresses in order for associating HA_UP Comms Case to TwiddleNet hardware.
Solution: Allow comms case or dedicated WiFi network an allotted range of IP addresses and assign to TwiddleNet hardware via DHCP.

4) **Problem**: No specified Thai translator
Description: There was no specified translator to communicate with Thai counterparts volunteering as Tsunami Survivors
Solution: Identify translator prior to 1st dry run of scenario. Maintain the same volunteers as tsunami survivors to maintain continuity of experience and knowledge.

6) **Problem**: No covered area for rain
Description: No available tent for protection from weather elements. Unable to procure "pop-up" tent from nearby town
Solution: Procure "pop-up" tent from Bangkok

7) **Problem**: No lighting available for Humanitarian Assistance site
Description: For night-time scenario, Humanitarian Assistance site MUST have light for the following reasons:
a) SAFETY
b) CLEAR IMAGE CAPTURE
c) SET UP OF EQUIPMENT
Solution: Acquire generator(s) and flood lights

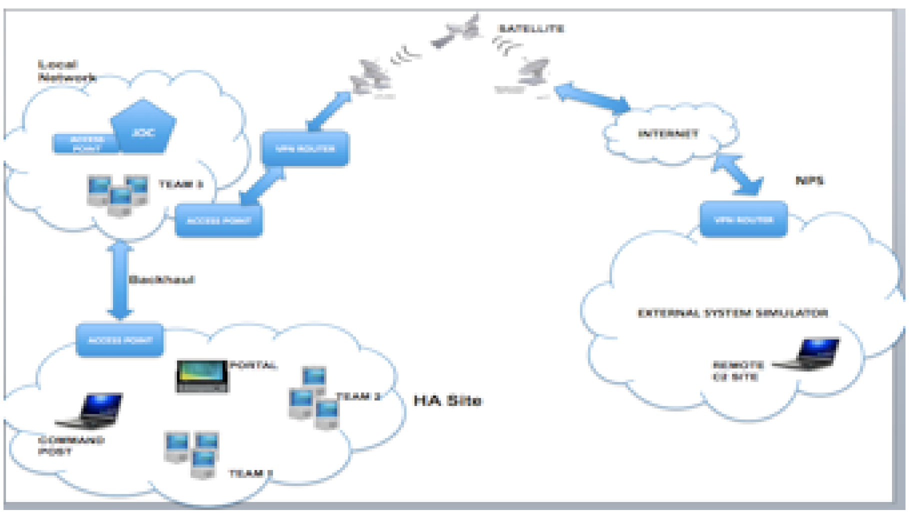
8) **Problem**: Bad radio comms / No comms plan used
Description: Radios used were not strong enough for clear comms from Humanitarian Site to JOCC. The comms plan that was available was not used.
Solution: Acquire stronger radios. Populate and use the comms plan.

APPENDIX G. TWIDDLENET FOURTH GENERATION ASSESSMENT REPORT

TWIDDLENET ASSESSMENT REPORT

DESCRIPTION:

- TwiddleNet is an NPS sponsored project to develop a smartphone-based system to facilitate instantaneous capture of data in support of medical triage / urban assault / warfighter patrol / HAZMAT response that can be tagged and disseminated using any mobile WiFi network.
- Utilizing Commercial-off-the-Shelf components, TN team members maintain complete autonomy of all captured data, which is shared among specified team members, stored for redundancy by the Command Post server and later discriminately shared.
- 100% gain of enhanced situational awareness for mobile monitoring during all types of scalable operations.



OBJECTIVES FOR CV09

- TwiddleNet performance data will be collected and analyzed during Crimson Viper 2009.
- The overall assessment strategy for CV09 TwiddleNet is to evaluate Effectiveness, Suitability, and Mission Impact of the various components under physically demanding conditions & with different network configurations.
- Document environmental data, network radius & uncontrollable variables

- Document environmental data, network radius & uncontrollable variables
- Measures and data sources will address, COIs, Objectives, MOEs and MOSs as well as a data collection and analysis approach
- Experiment Overview:
  - All components assembled and end-to-end transmissions confirmed by TN Cmd Post
  - Access to images/data on Cmd Post server tests from remote locations
  - Handhelds tested at different distances for reliability / speed of data transfer
  - System continuity documentation, troubleshooting, and course correction
  - System test of "Group Feature" and simultaneous data multithreading
  - WiFi cloud area tested with Fly Away Kit

RESULTS

- Analysis Result 1 - 6: Successfully completed all objectives. Analysis of results contained in conclusions.

Measure	Source	Product
MOE 1-1-1: Performance reliability of TwiddleNet system	TCA/OCA	95%
MOE 1-1-2: Percent of data captured and shared	TCA/OCA	95%
MOE 1-1-3: Percent of data received	TCA/OCA	95%
MOE 1-1-4: Percent of software reliability	TCA/OCA	100%
MOE 1-1-5: Percent of hardware reliability	TCA/OCA	95%

Measure	Source	Product
MOE 1-3-1: Maximum outdoor operating distance of Handheld Devices and TwiddleNet System	TCA/OCA	80 -100 yds (Low interference)
MOE 1-3-2: Maximum indoor operating distance of Handheld Devices and TwiddleNet System	TCA/OCA	100 yds (Low interference)
MOE 1-3-3: Maximum outdoor sensing range of Handheld Devices to OQO	TCA/OCA	80 – 100 yds (Low interference)
MOE 1-3-4: Maximum indoor sensing range of Handheld Devices to OQO	TCA/OCA	100 yds (Low interference)

Measure	Source	Product
MOE 1-2-1: TwiddleNet system ruggedization	TCA/OCA	80%
MOE 1-2-2: Percent of accurate data received / shared in the field	TCA/OCA	100%
MOE 1-2-3: User identification accuracy rating	TCA/OCA	100%
MOE 1-2-4: Ease of use / setup by Warfighter	TCA/OCA	100%
MOE 1-2-5: Climate effects: Temperature and Humidity	TCA/OCA	0%

Measure	Source	Product
MOE 2-1-1: Average time to set up system	TCA/OCA	20 mins
MOE 2-1-2: Average time for system to be fully operational	TCA/OCA	20 mins
MOE 2-1-3: Average battery life of Handheld Devices	TCA/OCA	2 hrs
MOE 2-1-4: Average battery life of OQO	TCA/OCA	6 hrs
MOE 2-1-5: Number and type of batteries	TCA/OCA	N/A

Measure	Source	Product
MOE 2-2-1: Is the TwiddleNet system man portable?	TCA/OCA	YES
MOE 2-2-2: Is the system easy to maintain?	TCA/OCA	YES
MOE 2-2-3: Are power requirements reasonable?	TCA/OCA	YES (Portable Batteries / Generator)

Measure	Source	Product
MOE 2-3-1: Is each GUI easy to comprehend and monitor?	TCA/OCA	YES
MOE 2-3-2: Does the TwiddleNet system enhance user situational awareness?	TCA/OCA	YES
MOE 2-3-3: How much training time is required for the user?	TCA/OCA	2-4 hrs.
MOE 2-3-4: Is it easy to correct errors in operation?	TCA/OCA	YES
MOE 2-3-5: Is adequate documentation available for the user to set system up, and troubleshoot problems of operation?	TCA/COA	YES

CONCLUSIONS

- 95% Overall success rate
- 95% Performance Reliability due to minor issues with data sharing
- 80% Ruggedization – subjective score based on my assessment
- 20% Degradation with operating distance – Not completely understood. More research w/ Dr. Singh

RECOMMENDATIONS

- Major Technical Issues
  - Nothing to Report
- Minor Technical Issues
  - WiFi Cloud reliability
  - WiFi must be turned off on handhelds when in sleep mode
    - To accommodate conservation of battery
  - System reliability during periods of idleness
    - Handhelds must be used at least once every hour to maintain connectivity to system

- Path Ahead
  - Purchase new Smartphone with more RAM, longer battery life, better camera
    - Increase robustness
  - Enlarge WiFi cloud
    - Purchase outdoor access points to create WAN
  - Explore possibility of use with other technologies, i.e. UAVs

DISTRO

Unclassified

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